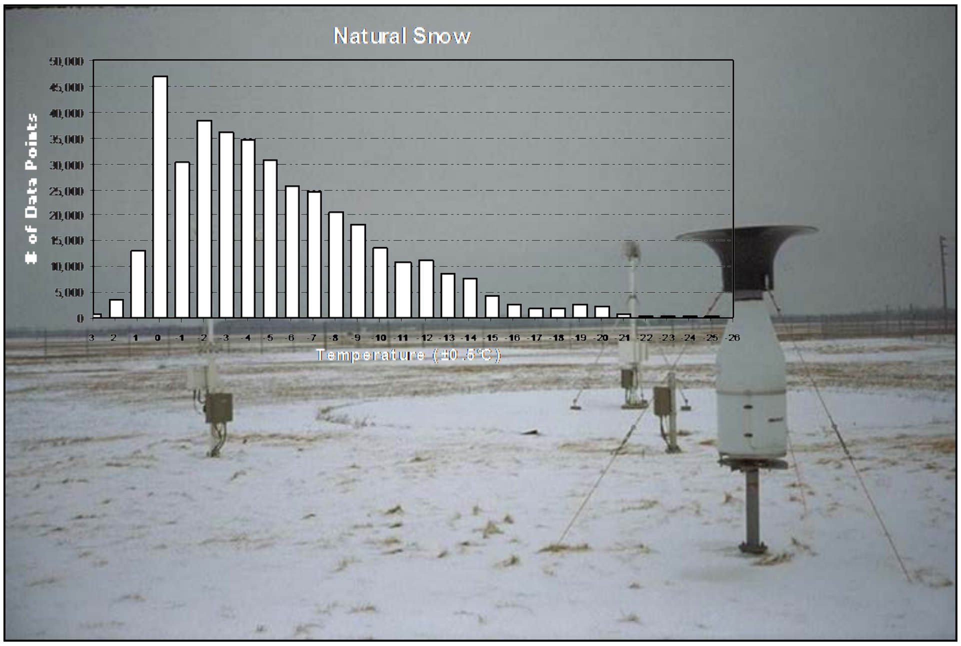
TP 14444E

Winter Weather Impact on Holdover Time Table Format (1995-2005)



Prepared for
Transportation Development Centre

In cooperation with

Civil Aviation
Transport Canada

Prepared by

APS Aviation Inc.

October 2005
Final Version 1.0

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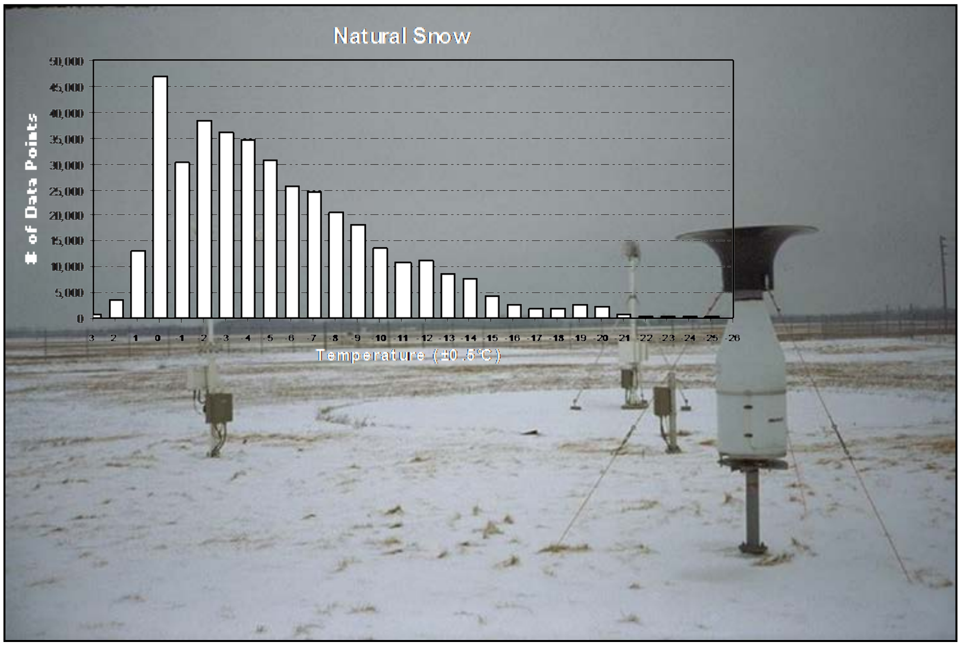

by

Nicoara Moc

October 2005
Final Version 1.0

The contents of this report reflect the views of APS Aviation Inc. and not necessarily the official view or opinions of the Transportation Development Centre of Transport Canada.

The Transportation Development Centre does not endorse products or manufacturers. Trade or manufacturers' names appear in this report only because they are essential to its objectives.

DOCUMENT ORIGIN AND APPROVAL RECORD

Prepared by: Nicoara Moc (Project Analyst)

Approved by: Jean Valiquette, President, APS Aviation Inc.

This report was prepared and signed by Nicoara Moc, reviewed and signed by John D'Avirro, and approved and signed by Jean Valiquette in October 2005 as part of the first submission to Transport Canada (Final Draft 1.0). A final Transport Canada technical and editorial review was completed in September 2017; Nicoara Moc and Jean Valiquette were not available to participate in the final review or to sign the current version of this report.

Reviewed by:

Notarius

John D'Avirro, Eng.
Program Manager

November 22, 2017
Date

Un sommaire français se trouve avant la table des matières.

PREFACE

Under contract to the Transportation Development Centre of Transport Canada, APS Aviation Inc. (APS) has undertaken a research program to advance aircraft ground de/anti-icing technology. The specific objectives of the APS test program are the following:

- To develop holdover time data for all newly-qualified de/anti-icing fluids;
- To conduct endurance time tests in frost on various test surfaces;
- To assist with the operational evaluation of Type III fluids;
- To finalize the laboratory snow test protocol with Type II/III and IV fluids;
- To evaluate weather data from previous winters to establish a range of conditions suitable for the evaluation of holdover time limits;
- To assist the SAE G-12 Ground Equipment Subcommittee in evaluating forced air-assist systems;
- To evaluate the possibility of using a fluid failure sensor in holdover time testing;
- To conduct endurance time tests on non-aluminum plates;
- To examine the effect of heat on Type II, III and IV fluid endurance times;
- To provide support for human factor tactile tests; and
- To conduct general and exploratory de/anti-icing research.

The research activities of the program conducted on behalf of Transport Canada during the winter of 2004-05 are documented in nine reports. The titles of the reports are as follows:

- TP 14443E Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2004-05 Winter;
- TP 14444E Winter Weather Impact on Holdover Time Table Format (1995-2005);
- TP 14445E Evaluation of Type IV Fluids Using FedEx Forced Air Assist Equipment;
- TP 14446E A Sensor for Determining Anti-Icing Fluid Failure: Phase II;
- TP 14447E Effect of Heat on Endurance Times of Anti-Icing Fluids;
- TP 14448E Aircraft Ground Deicing Fluid Endurance Times on Composite Surfaces;
- TP 14449E Development of Ice Samples for Visual and Tactile Ice Detection Capability Tests;
- TP 14450E Comparison of Human Ice Detection Capabilities and Ground Ice Detection Performance Tests on Wing at PMG; and
- TP 14451E Aircraft Ground Icing Research General Activities During the 2004-05 Winter.

In addition, an interim report entitled *Substantiation of Aircraft Ground Deicing Holdover Times in Frost Conditions* will be written.

This report, TP 14444E, has the following objective:

- To review the Holdover Time Table format using Winter Weather Data.

This objective was met by acquiring and analysing winter weather data from six meteorological stations in Quebec, Canada. This information was used to review and assess the format of the holdover time tables.

This research project has been funded by the Civil Aviation Group of Transport Canada.

PROGRAM ACKNOWLEDGEMENTS

This multi-year research program has been funded by the Civil Aviation Group, Transport Canada with support from the Federal Aviation Administration, William J. Hughes Technical Center, Atlantic City, NJ. This program could not have been accomplished without the participation of many organizations. APS would therefore like to thank the Transportation Development Centre of Transport Canada, the Federal Aviation Administration, National Research Council Canada, the Meteorological Service of Canada, and several fluid manufacturers.

APS would also like to acknowledge the dedication of the research team, whose performance was crucial to the acquisition of hard data. This includes the following people: Stephanie Bendickson, Nicolas Blais, Michael Chaput, Sami Chebil, John D'Avirro, Peter Dawson, Stéphane Gosselin, Mark Mayodon, Chris McCormack, Nicoara Moc, Filomeno Pepe, Marco Ruggi, Joey Tiano, Kim Vepsa, and David Youssef.

Special thanks are extended to Barry Myers, Frank Eyre and Yagusha Bodnar, who on behalf of the Transportation Development Centre, have participated, contributed and provided guidance in the preparation of these documents.

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The author of this report would like to acknowledge and thank the Meteorological Service of Canada for their diligence and commitment in providing all weather data required for this project.

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Several research reports for testing of de/anti-icing technologies were produced for previous winters on behalf of Transport Canada. These are available from the Transportation Development Centre (TDC). Nine reports (including this one) were produced as part of this winter's research program. Their subject matter is outlined in the preface. This research project has been funded by the Civil Aviation Group of Transport Canada.

16. Abstract

This study examines the frequency of occurrence of the various winter weather conditions experienced during ground deicing of aircraft with a view to recommending and supporting immediate and future changes to the format of the holdover time tables for SAE Type I, II and IV anti-icing fluids.

Data were acquired from Meteorological Service of Canada (MSC) for six automated weather stations in the province of Quebec, Canada. A total of 6 547 hours of snowstorm data recorded between 1995-96 and 2004-05 and 453 hours of freezing rain and freezing drizzle data were analysed. The data set included 911 hours of snowstorm data from the 2004-05 winter.

In addition, data from an extensive hourly observation weather information database for Montreal was analyzed in an attempt to determine the frequency of occurrence of ice pellet conditions. The observation period was from January 1, 1990 to December 31, 2001. It was found that the ice pellet occurrences accounted for less than two percent of all precipitation conditions during the winter months. Another dataset collected over the 2004-05 winter season included 52 hours of ice pellet conditions; the results of this analysis indicate that the intensity of ice pellets is less than 25 g/dm²/h 89 percent of the time.

This report contains recommendations to continue the weather surveys.

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15. Remarques additionnelles (programmes de financement, titres de publications connexes, etc.)

Plusieurs rapports de recherche d'années antérieures sur les essais de technologies de dégivrage et d'antigivrage ont été produits pour le compte de Transports Canada. Ils sont disponibles du Centre de développement des transports (CDT). Le programme de la saison hivernale a donné lieu à neuf rapports (dont celui-ci). On trouvera dans la préface l'objet de ces rapports. Ce projet de recherche a été financé par l'Aviation civile de Transports Canada.

16. Résumé

La présente étude examine la fréquence des différents événements météorologiques hivernaux qui se produisent durant le dégivrage d'aéronefs au sol, dans le but de recommander et d'appuyer des changements immédiats et futurs au format des tableaux d'efficacité des liquides d'antigivrage de types I, II et IV de la SAE.

Les données, obtenues auprès du Service météorologique du Canada (SMC), provenaient de six stations météorologiques automatisées situées au Québec, Canada. Un total de 6 547 heures de données de précipitations neigeuses, enregistrées entre 1995-96 et 2004-05, et plus de 453 heures de données de pluie verglaçante, ont été analysées. Sont comprises dans l'ensemble de données plus de 911 heures de données de précipitations neigeuses recueillies au cours de l'hiver 2004-05.

De plus, les données d'une base de données complète d'observations météorologiques horaires pour Montréal ont été analysées pour établir la fréquence de conditions de granules de glace. La période d'observation était du 1er janvier 1990 au 31 décembre 2001. L'étude a démontré que les cas de granules de glace représentaient moins de deux pourcent de toutes les conditions de précipitation des mois d'hiver. Un autre ensemble de données recueillies au cours de l'hiver 2004-2005 contenait 52 heures de conditions de granules de glace; les résultats de cette analyse démontrent que l'intensité des granules de glace est inférieure à 25 g/dm²/h, 89 pourcent du temps.

Ce rapport comprend des recommandations afin de faire suite aux enquêtes météorologiques.

17. Mots clés: Neige naturelle, taux de précipitation, données météorologiques, tableau de durées d'efficacité, fréquence et répartition des opérations de dégivrage.

18. Diffusion: Le Centre de développement des transports dispose d'un nombre limité d'exemplaires.

19. Classification de sécurité (de cette publication)	20. Classification de sécurité (de cette page)	21. Déclassification (date)	22. Nombre de pages	23. Prix
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EXECUTIVE SUMMARY

Under contract to the Transportation Development Centre (TDC) of Transport Canada (TC), APS Aviation Inc. (APS) undertook a study to evaluate precipitation data (precipitation rate/temperature data) from several winters to confirm the suitability of precipitation rate ranges used for holdover time (HOT) evaluation.

In addition, information collected from other research that relates to winter weather data has been compiled and is included in this report.

The information contained in this report can be used to further evaluate potential refinements to the format of the HOT tables.

Description and Processing of Data

A total of 6,547 hours of storm data points were developed from precipitation gauge logs for natural snow, including 911 hours from the 2004-05 data. Freezing rain/drizzle precipitation events were used to develop 453 hours of data. Data were acquired from the Meteorological Service of Canada (MSC) from instruments located at Montreal's Trudeau Airport and five other stations in the province of Quebec, Canada. The data were collected mostly from the winters of 1997-98 to 2004-05.

In addition, data from an extensive hourly observation weather information database for Montreal was analysed in an attempt to determine the frequency of occurrence of ice pellet conditions. The observation period was from January 1, 1990 to December 31, 2001.

Results and Conclusions

The weather database gathered between 1995-96 and 2004-05 from six sites in Quebec showed that current snow precipitation rate limits of 10 and 25 $g/dm^2/h$ are valid for moderate snow. The data analysis concluded that the column representing moderate snow in the HOT table encompasses only 23.9 percent of all snow events. This supports earlier data that led to the introduction of a light snow column in the Type I HOT table for precipitation rates of 4 to 10 $g/dm^2/h$. This column was used starting in the 2002-03 winter seasons.

Most snowfall events occur at rates less than 4 $g/dm^2/h$. A survey of actual winter operations conducted between 2000-01 and 2002-03 at a number of airports worldwide showed that snow comprises 56 percent of all deicing operations. In order to use longer HOT in the light snow column, further introduction of a very light snow column in the Type I HOT table was recommended and accepted at the 2003 SAE G-12 meeting. Also, it was concluded for the Type I HOT table that the temperature row of *-3 to -10 °C* should be replaced by two new temperature bands, *below -3 to -6 °C* and *below -6 to -10 °C*. Selection of -6 °C as the temperature break was found to be the most operationally advantageous.

Much of the information contained in this report was used to develop the format for the new Type III HOT table.

Recently, the format of the Type II/IV HOT tables was examined in an attempt to integrate some of the changes previously implemented in the Type I HOT table. At the 2004 SAE G-12 HOT Subcommittee meeting it was decided to merge the first two temperature rows of the Type II/IV tables into a new temperature band, *-3°C and above.* Additionally, the definition of the snow column was changed to include snow grains, and the frost column was changed from *Frost* to *Active Frost*.

The analysis of an hourly observation weather information database for Montreal showed that the ice pellet occurrences accounted for less than two percent of all precipitation conditions during the winter months. The dataset collected over the 2004-05 winter season included 52 hours of ice pellet conditions. During the 2004-05 winter, ice pellets occurred at ambient temperatures ranging from +5 to -13°C. The precipitation rate ranged between 1 and 80 g/dm²/h, with 95 percent of the rates equal to or below 40 g/dm²/h. Precipitation rates above 25 g/dm²/h represent only 11 percent of all the ice pellet occurrences.

The survey of actual winter operations showed that frost is the second most frequent type of deicing condition, and sufficient attention should be given to investigating and substantiating frost HOT, particularly for Type I fluids.

The limited database for freezing rain and drizzle indicates that the current temperature and rate limits for those conditions are valid. However, the database for these conditions is small and additional data would be useful.

Recommendations

The weather data survey has provided useful information and should be continued to generate more data, which is particularly needed for infrequent precipitation conditions such as ice pellets, freezing rain and freezing drizzle. Also, discussions between the regulators and industry members are suggested to enable the development and the possible implementation of a proposed HOT table template that could be followed for future HOT testing.

SOMMAIRE

En vertu d'un contrat avec le Centre de développement des transports (TDC) de Transports Canada (TC), APS Aviation Inc. (APS) a entrepris une étude pour évaluer les données de précipitation (données sur les taux et températures des précipitations) de plusieurs hivers, afin de confirmer la pertinence des plages de taux de précipitation utilisées pour l'évaluation des durées d'efficacité.

De plus, le présent rapport englobe aussi des données colligées à l'occasion d'autres recherches connexes.

L'information contenue dans ce rapport peut servir à évaluer la pertinence d'améliorations possibles à la présentation des tableaux des durées d'efficacité.

Description et traitement des données

Des points de données de précipitations neigeuses ont été établis à partir de relevés nivométriques couvrant un total de 6 547 heures, dont 911 heures pendant l'hiver 2004-05. Des périodes de précipitation de pluie/bruine verglaçante ont servi à générer des points de données couvrant plus de 453 heures. Ces données, obtenues auprès du Service météorologique du Canada (SMC), provenaient d'instruments situés à l'Aéroport Pierre-Elliott-Trudeau, Montréal et de cinq autres stations du Québec, Canada. Les données ne couvraient que les hivers 1997-1998 à 2004-05.

De plus, les données d'une base de données complète d'observations météorologiques horaires pour Montréal ont été analysées pour établir la fréquence de conditions de granules de glace. La période d'observation était du 1er janvier 1990 au 31 décembre 2001.

Résultats et conclusions

La base de données météorologiques recueillie entre 1995-96 et 2004-05 sur six emplacements du Québec a démontré que les limites actuelles de taux de précipitation de neige de 10 et 25 g/dm^2/h sont valides dans le cas de neige modérée. L'analyse des données a conclu que la colonne du tableau actuel de durées d'efficacité qui illustre la neige modérée ne couvre que 23,9 pourcent de tous les événements de neige. Cette analyse confirme les données précédentes qui ont mené à l'introduction d'une colonne de neige légère dans le tableau de durées d'efficacité des liquides de type I, pour les taux de précipitation de 4 à 10 g/dm^2/h. Cette colonne a servi à partir de l'hiver 2002-03.

La plupart des chutes de neige se produisent à un taux inférieur à 4 g/dm^2/h. Une étude des opérations hivernales actuelles, menée entre 2000-01 et 2002-2003 à un certain nombre d'aéroports à travers le monde, a démontré que la neige fait l'objet de 56 pourcent de toutes les opérations de dégivrage. Afin d'utiliser de plus grandes durées d'efficacité dans la colonne de neige légère, l'introduction additionnelle d'une colonne de neige très légère au tableau des durées d'efficacité des liquides de type I a été recommandée et acceptée à la réunion de 2003 du G-12 de la SAE. De plus, l'analyse a conclu que, pour le tableau de durées d'efficacité des liquides de type I, la rangée des températures de *-3 à -10ºC* devrait être retirée et remplacée par deux nouvelles rangées, *au-dessous de -3 à -6ºC* et *au-dessous de -6 à -10ºC*. Le choix de -6ºC comme température limite produit le mélange de durées d'efficacité le plus avantageux.

Une grande partie de l'information de ce rapport a servi à développer le format du nouveau tableau de durées d'efficacité des liquides de type III.

Dernièrement, le format des tableaux de durées d'efficacité des liquides de types II et IV a été examiné, dans l'espoir d'y intégrer certains des changements mis en place auparavant dans le tableau de durées d'efficacité des liquides de type I. À la réunion de 2004 du sous-comité G-12 de la SAE sur les durées d'efficacité, il a été convenu de fusionner les deux premières rangées de températures des tableaux de types II et IV en une nouvelle plage de températures, *-3°C et plus.* De plus, la définition de la colonne de neige a été modifiée pour y inclure la neige en grains. La colonne de givre a aussi été changée de *givre* à *givre actif*.

L'analyse d'une base de données d'observations météorologiques horaires à Montréal a démontré que les cas de granules de glace ne représentent que moins de deux pourcent de toutes les précipitations des mois d'hiver. L'ensemble de données recueillies au cours de l'hiver 2004-2005 comprenait 52 heures de conditions de granules de glace. Durant l'hiver 2004-2005, les granules de glace se sont formés à des températures ambiantes entre +5 et -13°C. Le taux de précipitation se situait entre 1 et 80 g/dm^2/h, 95 pourcent des taux se situant à 40 g/dm^2/h ou moins. Les taux de précipitation de plus de 25 g/dm^2/h ne représentent que 11 pourcent de tous les cas de granules de glace.

L'enquête sur les opérations hivernales réelles a démontré que le givre est deuxième en importance parmi les conditions de dégivrage et suffisamment d'attention devrait être portée à l'étude et à la justification des durées d'efficacité dans le givre, en particulier pour les liquides de type I.

La base de données limitée sur la pluie et la bruine verglaçantes démontre que les limites actuelles de température et de taux sont valides dans ces conditions. Cependant, cette base de donnée est petite et des données additionnelles seraient utiles.

Recommandations

L'étude sur les données météorologiques a produit de l'information utile et devrait être poursuivie pour générer davantage de données. Ceci est particulièrement nécessaire dans les rares cas de précipitations sous forme de granules de glace, de pluie verglaçante et de bruine verglaçante. Des discussions entre les organismes de réglementation et les membres de l'industrie sont également recommandées, afin de permettre le développement et la mise en application possible d'un modèle de tableau de durées d'efficacité qui pourrait servir aux essais futurs sur les durées d'efficacité.

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GLOSSARY

APS	APS Aviation Inc.
FAA	Federal Aviation Administration
HOT	Holdover Time
MSC	Meteorological Service of Canada
NRC	National Research Council Canada
OAT	Outside Air Temperature
READAC	Remote Environmental Automatic Data Acquisition Concept
TC	Transport Canada
TDC	Transportation Development Centre

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1. INTRODUCTION

Under winter precipitation conditions, aircraft are cleaned with a freezing point depressant fluid and protected against further accumulation by an additional application of such a fluid, possibly thickened to extend the protection time. Aircraft ground deicing had, until recently, never been researched and there is still limited understanding of the hazard and of what can be done to reduce the risks posed by the operation of aircraft in winter precipitation conditions. This "winter operations contaminated aircraft – ground" program of research is aimed at overcoming this lack of knowledge.

Over the past several years, the Transportation Development Centre (TDC), Transport Canada (TC) has managed and conducted de/anti-icing related tests at various sites in Canada; it has also co-ordinated worldwide testing and evaluation of evolving technologies related to de/anti-icing operations with the co-operation of the US Federal Aviation Administration (FAA), the National Research Council (NRC), Atmospheric Environment Services, several major airlines, and deicing fluid manufacturers. The TDC is continuing its research, development, testing and evaluation program.

Under contract to TDC, APS Aviation Inc. (APS) undertook a test program to collect frost data on flat plates in natural conditions to substantiate the aircraft ground de/anti-icing fluid holdover times (HOT). This report contains the results of an analysis conducted by APS between 1995-96 and 2004-05 on the evaluation of precipitation rate data. It also encompasses all the data presented in the 2003-04 TC report, TP 14375E, *Winter Weather Impact on Holdover Time Table Format (1995-2004)*, (1). This study formed part of the 2004-05 winter research program on deicing. The project is described in the work statement presented as Appendix A.

Holdover time (HOT) tables are developed as guidelines to be used by pilots in aircraft departure planning under different winter weather conditions. Each HOT table is composed of cells, with each cell containing a HOT range for a specific temperature range and category of precipitation. The time range in each cell is defined by a “lower” time and an “upper” time; these values represent the failure time of the fluid at the upper and lower precipitation rate range, respectively.

There are four standard types of fluid: Type I, Type II, Type III and Type IV. Aircraft are deiced using heated Type I and Type III fluids. Type II and Type IV fluids are anti-icing fluids that are applied following aircraft deicing, with Type II fluids being thicker and more viscous than Type I or Type III fluids. Type IV fluids are designed to provide the utmost in HOT protection.

The Type I, Type III and Type II/IV HOT table formats have undergone significant change since the early 1990s. While the changes have been made primarily to improve and address safety concerns of many individuals and organizations involved in the deicing industry, a structured approach has not been taken for implementing changes. In fact, many of the changes have been made on a year-by-year basis at industry meetings. These changes were typically minor in nature, but after nearly ten years, the impact on the HOT is more significant. More recently, several changes have been made to improve and simplify the tables, while simultaneously ensuring that a high level of safety is maintained when the tables are put to use. Proposals for changes to the HOT tables have been made by TC, and these include new temperature breakdowns to better reflect winter precipitation conditions, expansion of the snow column to reflect its high usage, and removal of unnecessary HOT ranges in certain columns to result in a single value. To substantiate these changes, a survey of airlines at several international airports was conducted. The survey provided information relating to the frequency of deicing operations as a function of weather condition and temperature. The analysis of the results from the 3-year airline survey are presented in Section 3 of the 2003-04 TC report, TP 14375E, *Winter Weather Impact on Holdover Time Table Format (1995-2004)*, (1).

Between 2000-01 and 2002-03, the winter operations survey conducted by TC concluded that, for the reporting centres the distribution of types of deicing operations was:

a) Snow 56 percent;

b) Frost 33 percent; and

c) Other 11 percent.

The *other* category consisted of freezing rain, freezing drizzle, freezing fog, cold-soaked wing and rime ice.

Several years ago, holdover times for snow were evaluated or developed using lower and upper precipitation rates of 10 and 25 g/dm²/h for all air temperatures (0, -3, -14 and -25°C). Initially it was believed that precipitation rates of 10 to 25 g/dm²/h do not occur below -14°C. The data collected demonstrated that such high precipitation rates, although they do exist, are less frequent at these lower temperatures. As a result, it was concluded that the HOT rate limits of 10 and 25 g/dm²/h are representative of natural snow conditions and need to be maintained.

The main purposes of this study were to:

d) Further evaluate weather precipitation data (precipitation rate/temperature data) over several recent winters and substantiate the suitability of proposed data ranges for the evaluation of upper and lower HOT limits; and

e) Review the surveys of winter weather data and apply them to evaluate the format of the HOT tables.

The following section of this report (Section 2) presents an analysis of the natural snow and freezing rain/drizzle data collected in 2004-05 from six stations in Quebec and provides, in conjunction with data from nine previous winter seasons, a distribution of precipitation events by temperature and precipitation rate. Additionally, it provides an analysis of the data collected under ice pellet conditions during the 2004-05 winter season. Section 3 presents a summary of the findings from the operations survey data collected between 2000-01 and 2002-03, by showing the distribution of deicing operations worldwide. Section 4 summarizes the current and proposed changes to the format of the HOT tables. Section 5 presents a brief summary of the frost deposition rates measured in natural conditions. The conclusions and recommendations are presented in Sections 6 and 7 of this report.

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2. DESCRIPTION AND ANALYSIS OF NATURAL SNOW, FREEZING RAIN/DRIZZLE AND ICE PELLET DATA

2.1 Methodology

This section describes the methods used to evaluate weather data that were collected to study the distribution of precipitation rates and temperatures for natural snow, freezing rain/drizzle and ice pellets.

2.1.1 Sources of Data and Test Sites

The precipitation events analysed in this report were extracted from the following:

a) The Dorval Remote Environmental Automatic Data Acquisition Concept (READAC) log for the years 1995 to 1999;

b) The data logs from 1998 to 2005 for the three CR21X stations at Rouyn, Pointe-au-Père (Mont-Joli), and Ancienne Lorette (Quebec City);

c) The data log from the Trudeau Airport CR21X station from 1998 to 2005;

d) The data logs for 2000 to 2005 from two additional CR21X stations located in High Falls (near Ottawa, Ontario) and Frelighsburg (in Quebec's Eastern Townships); and

e) An extensive hourly observation weather information dataset spanning between January 1, 1990 and December 31, 2001.

The data collected by APS from various sources extending back to the 1991-92 winter season, using different precipitation gauges, are shown in Table 2.1. Each site is identified on a map of Quebec, shown in Figure 2.1. The data, starting with the 1995-96 winter season, analysed and sorted by temperature ranges, are included in Appendix B.

Two similar studies were conducted. One study was conducted by APS in the 1993-94 to 1994-95 winters using data collected from three weather stations located around Montreal. The Meteorological Service of Canada (MSC) carried out a similar study in 1995 using data collected at the Lester B. Pearson International Airport in Toronto. Overall, the data sets from MSC and APS were found to be similar enough to merit a comparison for temperature ranges above -7°C. Below that temperature, the MSC data contains no high rate precipitation points. These two studies can be found in Appendices C and D of TC report, TP 13993E*, Impact of Winter Weather on Holdover Time Table Format (1995-2002)*, (2).

Table 2.1: Summary of Winter Weather Data

				CR21X									
PROJECT #	YEAR	PLATE PAN	READAC YUL	WUY (Rouyn)	WTQ (Dorval)	WQB (Québec)	WYQ (Pointe-au-Père)	WFQ (Frelighsburg)	XHF (High Falls)	CITY OF MONTREAL (Fisher/Porter)	OMBROMETER THIES	TIPPING BUCKET	YYZ
	1990/91	Test period										X(3)	
	1991/92	Test period								X(6)	X(3)		
	1992/93	Test period								X(6)	X(3)		
C1171	1993/94	Test period								X(1) (Three stations)	X(3) (Shielded)		
CM1222	1994/95	Test period	X(1)										
CM1283	1995/96	15 min	X(2)										X(4)
CM1338	1996/97	15 min	X(2)		X(5)								X(4)
CM1380	1997/98	5-15 min	X(2)	X(2)	X(2)	X(2)	X(2)						
CM1514	1998/99	5-15 min	X(2)	X(2)	X(2)	X(2)	X(2)						
CM1589	1999/00	5-15 min		X(2)	X(5)	X(2)	X(2)	X(2)	X(2)				
CM1680	2000/01	5-15 min		X(2)	X(2)	X(2)	X(2)	X(2)	X(2)				
CM1680(01-02)	2001/02	5-15 min		X(2)	X(2)	X(2)	X(2)	X(2)	X(2)				
CM1747	2002/03	5-15 min		X(2)	X(2)	X(2)	X(2)	X(2)	X(2)				
CM1892	2003/04	5-15 min		X(2)	X(2)	X(2)	X(2)	X(2)	X(2)				
CM1892	2004/05	5-15 min		X(2)	X(2)	X(2)	X(2)	X(2)	X(2)				

(1) Data analysed for Transport Canada in 1996.

(2) Data used for this report.

(3) Unusable data - precipitation rate determined by this gauge was always lower than other instruments.

(4) Analysis completed by AES at YYZ.

(5) Unusable data - scattered data (gauge was not shielded).

(6) Data archived.

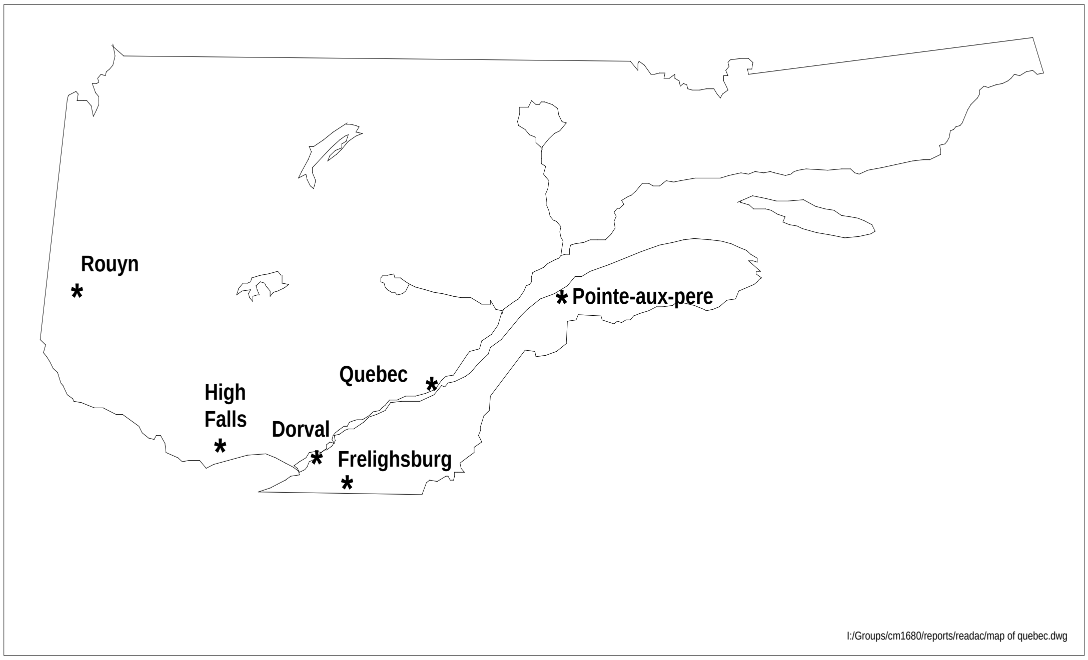

Figure 2.1: Map of Precipitation Gauge Locations

Unless otherwise specified, all precipitation rates analysed in this report were extracted from the CR21X data logs received from MSC for each of the six Quebec weather stations that are part of this study.

2.1.2 Equipment

Over the years, both the READAC and CR21X stations were used to measure precipitation rates. Starting with the 2003-04 winter, the use of the READAC equipment at Trudeau Airport was discontinued by MSC. The READAC precipitation gauge consists of a bucket partially filled with an antifreeze compound so that it effectively captures snow. A weighing transducer shaft provides instantaneous displacement values of the bucket in terms of millimetres of precipitation. This shaft displacement is transmitted every 2.5 seconds and averaged every minute in an attempt to eliminate spurious data caused by gusts of wind and temperature-induced contraction and expansion of the sensor. The READAC instrument has a resolution of 0.5 mm (5 g/dm²).

The CR21X station operates on the same principle as the READAC station and has an accuracy of 0.1 mm (1 g/dm²). The station measures precipitation with a Fisher Porter precipitation gauge and the readings are logged with a CR21X data logger. A more detailed description of the CR21X equipment can be found in Appendix C.

Precipitation rates tend to fluctuate rapidly during snowstorms. The weight resolution of the READAC stations is less accurate in measuring rapid changes compared to the CR21X station. The data from the CR21X station therefore required less smoothing before it could be interpreted. The increased resolution of the CR21X weighing transducer allows better observation of short periods with heavy precipitation.

For this project, the measuring instruments used to record weather precipitation data were owned and operated by MSC, and these instruments were calibrated according to their standards. The data were acquired for the purpose of this project.

2.1.3 Description of Analytical Methods

Precipitation rate data were averaged at intervals that correspond to three specified periods typically used in the HOT tables: 6 minutes for Type I fluids, 20 minutes for Type II fluids, and 35 minutes for Type IV fluids. For natural snow, data were classified into five temperature ranges: *above 0°C*, *0 to -3°C*, *-3 to -7°C, -7 to -14°C* and *-14 to -25°C*. For freezing rain/drizzle, data were classified into two ranges: *0 to -3°C* and *-3 to -10°C*.

Snowfalls at Trudeau Airport were tracked from 1995 to 2005 using the Monthly Meteorological Data Summary provided by MSC. This summary includes meteorological data such as temperature, wind speed and direction, dew point temperature, and humidity on an hourly basis, and precipitation type and total accumulation on a daily basis. An example of the Monthly Meteorological Summary for Montreal is included in Appendix D. The last page of the summary (D-6) states whether it snowed on a particular day and the first page (D-1) provides the total snow accumulation for each day. Based on this information, the precipitation and temperature data were extracted from READAC logs on a minute-by-minute basis and added to a database. The CR21X data were treated in a similar way.

Starting with the winter of 2004-05, the number of Monthly Meteorological Data Summaries produced by MSC has reduced as the data were made available on the MSC website. As a result, for the 2004-05 winter season, APS used Monthly Summaries for Montreal, Quebec and Pointe-au-Père (Mont-Joli), and the information posted online for Rouyn, Frelighsburg and High Falls.

Periods of snowfall were identified using either the Environment Canada summaries or the weather database available online, and snow accumulation data were added to the database along with ambient air temperatures. The temperatures were then linearly interpolated throughout the hour on a minute-by-minute basis.

2.1.4 Linearization of Cumulative Snow Weight Data

Precipitation rates were calculated in a two-step procedure.

First, using an algorithm developed by APS, the total precipitation for each snowfall was linearized to produce a smooth curve. Table 2.2 shows an example of linearized values for total snow accumulation.

Secondly, precipitation rates were calculated according to the linearized total snow accumulation values and the time between readings. This procedure is described in Section 2.3.

Figure 2.2 shows an output from the CR21X data logger recording the output from the precipitation gauges and the linearized data for a typical snowfall. The precipitation gauge output, sensitive to 1 g/dm², is plotted versus time to establish the periods of snowfalls.

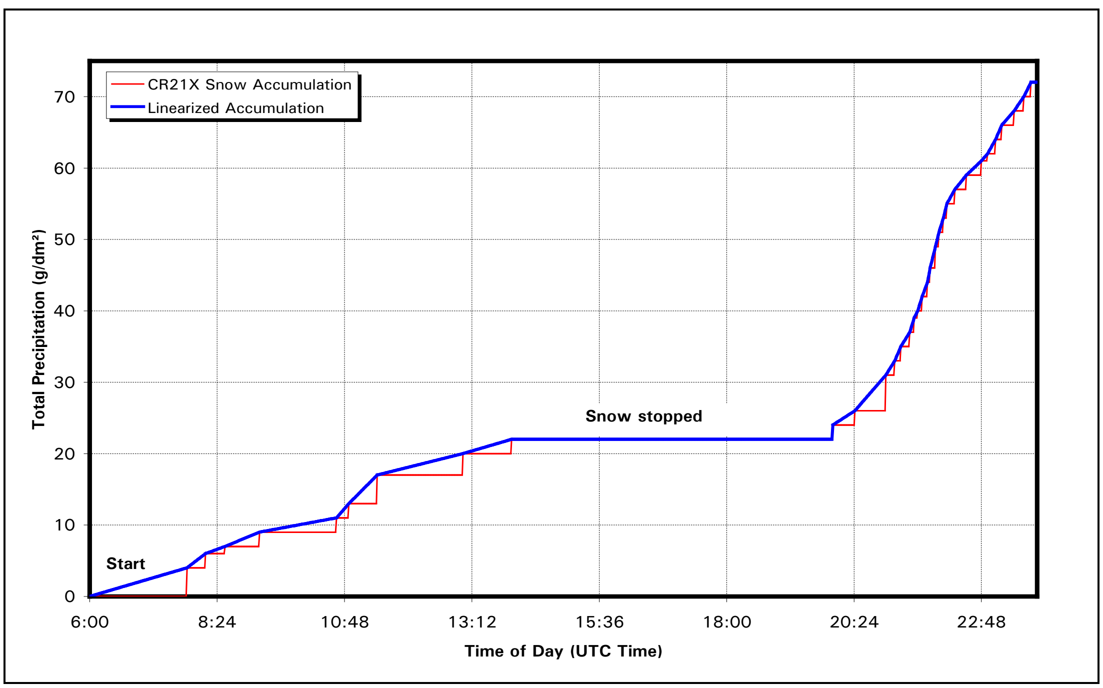

Figure 2.2: CR21X Precipitation Gauge Cumulative and Linearized Precipitation

As seen in Figure 2.2 intervals when snowfalls were interrupted for long periods of time were excluded from the analysis. Subsequent snowfalls were treated in a similar manner. The first and last indications of snowfall (first and last 1 g/dm^2) were excluded due to uncertainty about the precise start and end time of the snowfall.

Periods of low-rate snow precipitation might have been overlooked due to long interruptions in bucket weight changes. It is difficult to establish whether these weight changes were due to constant low rate precipitation or long periods with no precipitation and short intervals of higher precipitation. The start and end of a snowstorm are difficult to establish because snow may start and end gradually at slow rates or abruptly at high rates. For several recent winters, light snowfalls over long periods of time were excluded. Starting with the 2000-01 winter season, it was established as a guideline that snowfalls with total precipitation of 2 cm over 6 hours be excluded; this analytical pattern was used for subsequent years.

Table 2.2: Sample of Linearized READAC Data

Location	Date	UTC Time	Temp (°C)	Type of Precip.	Total Snow Accumulation (g/dm²)	Linearized Total Snow Accumulation (g/dm²)
YUL	14/12/1995	21:16	-11.8	S-	**40**	**40**
YUL	14/12/1995	21:17	-11.7	S-	**40**	**40.16**
YUL	14/12/1995	21:18	-11.6	S-	**40**	**40.31**
YUL	14/12/1995	21:19	-11.6	S-	**40**	**40.47**
YUL	14/12/1995	21:20	-11.6	S-	**40**	**40.63**
YUL	14/12/1995	21:21	-11.6	S-	**40**	**40.78**
YUL	14/12/1995	21:22	-11.6	S-	**40**	**40.94**
YUL	14/12/1995	21:23	-11.5	S-	**40**	**41.09**
YUL	14/12/1995	21:24	-11.6	S-	**40**	**41.25**
YUL	14/12/1995	21:25	-11.6	S-	**40**	**41.41**
YUL	14/12/1995	21:26	-11.4	S-	**40**	**41.56**
YUL	14/12/1995	21:27	-11.4	S-	**40**	**41.72**
YUL	14/12/1995	21:28	-11.5	S-	**40**	**41.88**
YUL	14/12/1995	21:29	-11.5	S-	**40**	**42.03**
YUL	14/12/1995	21:30	-11.4	S-	**40**	**42.19**
YUL	14/12/1995	21:31	-11.4	S-	**40**	**42.34**
YUL	14/12/1995	21:32	-11.4	S-	**40**	**42.50**
YUL	14/12/1995	21:33	-11.4	S-	**40**	**42.66**
YUL	14/12/1995	21:34	-11.4	S-	**40**	**42.81**
YUL	14/12/1995	21:35	-11.4	S-	**40**	**42.97**
YUL	14/12/1995	21:36	-11.3	S-	**40**	**43.13**
YUL	14/12/1995	21:37	-11.3	S-	**40**	**43.28**
YUL	14/12/1995	21:38	-11.4	S-	**40**	**43.44**
YUL	14/12/1995	21:39	-11.4	S-	**40**	**43.59**
YUL	14/12/1995	21:40	-11.3	S-	**40**	**43.75**
YUL	14/12/1995	21:41	-11.3	S-	**40**	**43.91**
YUL	14/12/1995	21:42	-11.3	S-	**40**	**44.06**
YUL	14/12/1995	21:43	-11.3	S-	**40**	**44.22**
YUL	14/12/1995	21:44	-11.2	S-	**40**	**44.38**
YUL	14/12/1995	21:45	-11.2	S-	**40**	**44.53**
YUL	14/12/1995	21:46	-11.2	S-	**40**	**44.69**
YUL	14/12/1995	21:47	-11.2	S-	**40**	**44.84**
YUL	14/12/1995	21:48	-11.2	S-	**45**	**45.00**
YUL	14/12/1995	21:49	-11.2	S-	**45**	**45.29**
YUL	14/12/1995	21:50	-11.2	S-	**45**	**45.59**
YUL	14/12/1995	21:51	-11.2	S-	**45**	**45.88**
YUL	14/12/1995	21:52	-11.1	S-	**45**	**46.18**
YUL	14/12/1995	21:53	-11.1	S-	**45**	**46.47**
YUL	14/12/1995	21:54	-11.1	S-	**45**	**46.76**
YUL	14/12/1995	21:55	-11.1	S-	**45**	**47.06**
YUL	14/12/1995	21:56	-11.1	S-	**45**	**47.35**
YUL	14/12/1995	21:57	-11.1	S-	**45**	**47.65**
YUL	14/12/1995	21:58	-11.1	S-	**45**	**47.94**
YUL	14/12/1995	21:59	-11.0	S-	**45**	**48.24**
YUL	14/12/1995	22:00	-11.0	S-	**45**	**48.53**
YUL	14/12/1995	22:01	-11.0	S-	**45**	**48.82**
YUL	14/12/1995	22:02	-11.0	S-	**45**	**49.12**
YUL	14/12/1995	22:03	-11.0	S-	**45**	**49.41**
YUL	14/12/1995	22:04	-10.9	S-	**45**	**49.71**
YUL	14/12/1995	22:05	-10.8	S-	**50**	**50.00**

2.2 Description and Processing of Natural Snow, Freezing Rain/Drizzle and Ice Pellets Data

2.2.1 Natural Snow

During the 2004-05 winter season, 54,684 data points were collected for natural snow conditions at six stations in Quebec. These represent 911 hours of snowfall and an average of approximately 151 hours of snowfall at each station. More data were usable from 2004-05 winter than in past winters due to improvements in the CR21X stations.

The distribution of the 2004-05 data points across the six meteorological stations is summarized in Figure 2.3.

Table 2.3: Distribution of 2004-05 Snow Data Points by Station

Station	# of Data Points	%
Frelighsburg	6 041	11
Quebec	11 767	22
Montreal	9 390	17
Rouyn Noranda	10 726	20
Mont-Joli	10 125	18
High Falls	6 635	12
Total	**54 684**	**100**

The distribution of new data points from all stations, sorted by temperature, is listed in Table 2.4.

Table 2.4: Distribution of 2004-05 Snow Data Points by Temperature

Temperature Range	# of Data Points
Above 0°C	6 572
Between 0 and -3°C	12 187
Between -3 and -6°C	13 518
Between -6 and -10°C	11 218
Between -10 and -14°C	7 350
Between -14 and -25°C	3 839
Total	**54 684**

The distribution of data points for 2004-05, by temperature and in histogram format is shown in Figure 2.3.

The following observations should be noted:

a) 12.0 percent of the snowfalls occurred at temperatures above 0°C;
b) 22.3 percent of the snowfalls occurred within the range of 0 to -3°C;
c) 24.7 percent occurred between -3 and -6°C;
d) 20.5 percent occurred between -6 and -10°C;
e) 13.4 percent occurred between -10 and -14°C; and
f) 7.0 percent occurred between -14 and -25°C.

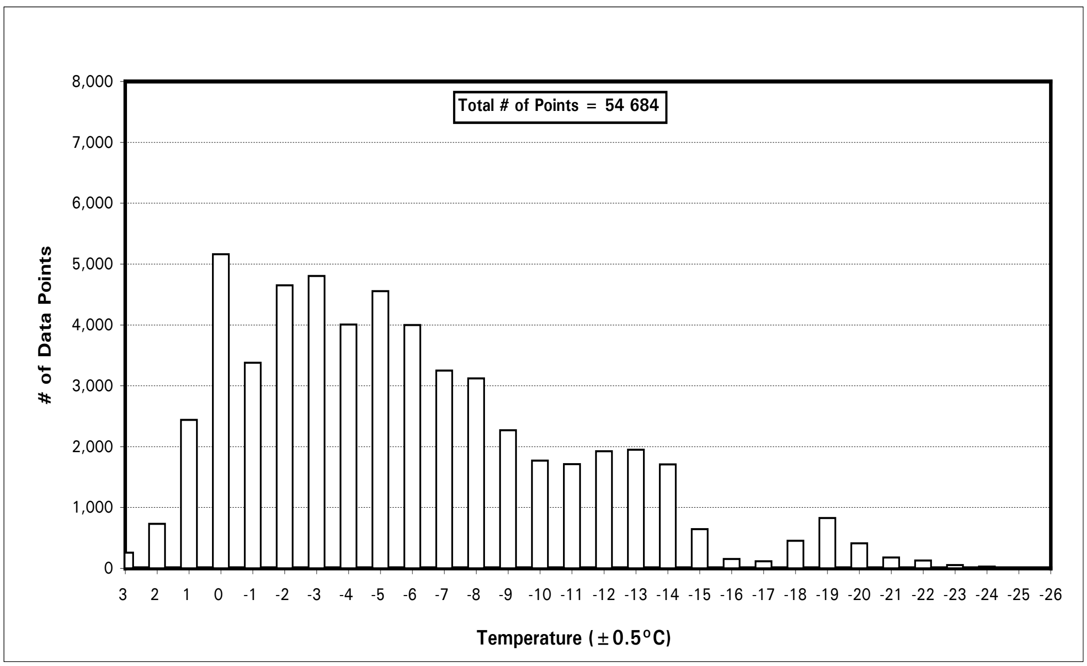

Figure 2.3: Temperature Distribution for 2004-05 Winter – Natural Snow

This is a consolidated report, encompassing all the data presented in TC report TP 14375E, *Winter Weather Impact on Holdover Time Table Format (1995-2004)*, (1). A total of 392,835 data points were collected for natural snow conditions from 1995-96 to 2004-05. On average, this represented over 100 hours of snowfall per year for each of the six stations in Quebec.

The distribution of snow data points over the ten years of observation is illustrated in Table 2.5.

Table 2.5: Distribution of Snow Data Points (1996 to 2005)

Year	# of Data Points	%
1995-98	39 426	10.0
1998-99	37 272	9.5
1999-00	43 927	11.2
2000-01	57 280	14.6
2001-02	55 026	14.0
2002-03	57 441	14.6
2003-04	47 779	12.2
2004-05	54 684	13.9
Total	**392 835**	**100**

The distribution of data points by temperature range is listed in Table 2.6.

Table 2.6: Temperature Distribution (1996 to 2005)

Temperature Range	# of Data Points
Above 0°C	45 968
Between 0 and -3°C	105 197
Between -3 and -6°C	96 107
Between -6 and -10°C	82 866
Between -10 and -14°C	41 252
Between -14 and -25°C	21 445
Total	**392 835**

Figure 2.4 shows the temperature breakdown of all data points collected from the winters of 1995-96 to 2004-05 for natural snow. The following observations should be noted:

a) 11.7 percent of the snowfalls occurred at temperatures above 0°C;

b) 26.8 percent of the snowfalls occurred within the range of 0 to -3°C;

c) 24.4 percent occurred between -3 and -6°C;

d) 21.1 percent occurred between -6 and -10°C;

e) 10.5 percent occurred between -10 and -14°C; and

f) 5.5 percent occurred between -14 and -25°C.

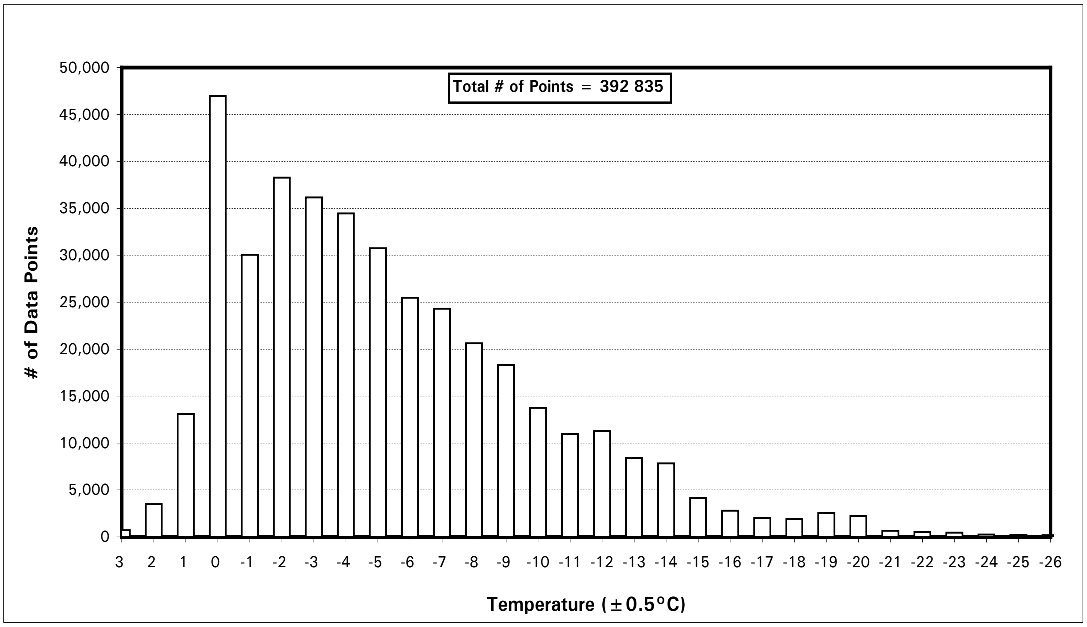

Figure 2.4: Temperature Distribution for the 1996-05 Winters – Natural Snow

2.2.2 Freezing Rain/Drizzle

During the 2004-05 winter, 1,503 data points were collected for Montreal and five other Quebec stations. These represent approximately 25 hours of freezing rain/drizzle data. The distribution of the data by temperature range is shown in Figure 2.5.

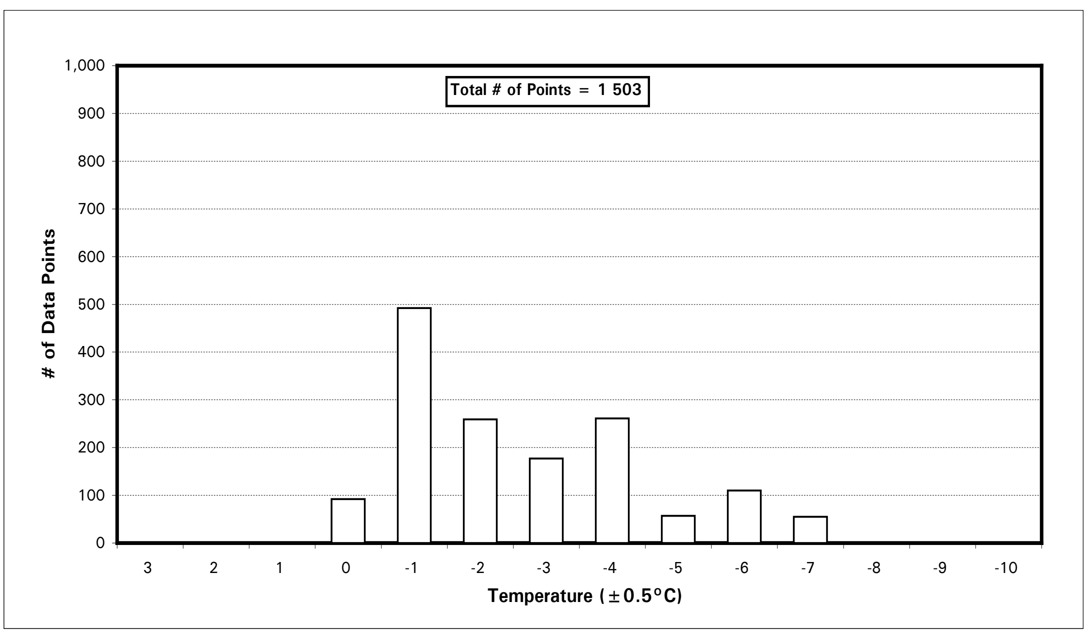

Figure 2.5: Temperature Distribution for 2004-05 – Freezing Rain/Drizzle

The distribution of the 2004-05 data points by temperature range is listed in Table 2.7.

Table 2.7: Distribution of 2004-05 Freezing Rain/Drizzle Data Points by Temperature

Temperature Range	# of Data Points
Above 0ºC	0
Between 0 and -3°C	942
Between -3 and -6°C	466
Between -6 and -10°C	95
Total	**1 503**

From 1996-97 to 2004-05, a total of 27,222 data points were collected for freezing rain/drizzle conditions. These represent approximately 453 hours of light freezing rain/drizzle data. Freezing rain/drizzle data were developed from CR21X and READAC logs. The 1998 ice storm data are included in this dataset.

The distribution of these data points over the nine years of observation is illustrated in Table 2.8.

Table 2.8: Distribution of Freezing Rain/Drizzle Data Points over the Last Nine Winters

Year	# of Data Points	%
1996-00	13 381	49.1
2000-01	785	2.9
2001-02	5 465	20.1
2002-03	3 859	14.2
2003-04	2 229	8.2
2004-05	1 503	5.5
Total	**27 222**	**100**

The distribution of data points by temperature range is listed in the Table 2.9.

Table 2.9: Distribution of Freezing Rain/Drizzle Data Points by Temperature 1996-97 to 2004-05

Temperature Range	# of Data Points
Above 0ºC	5 348
Between 0 and -3°C	10 991
Between -3 and -6°C	8 494
Between -6 and -10°C	2 389
Total	**27 222**

It should be noted that freezing rain/drizzle did not occur at temperatures below -10°C.

The distribution of these data points by temperature range is shown in Figure 2.6.

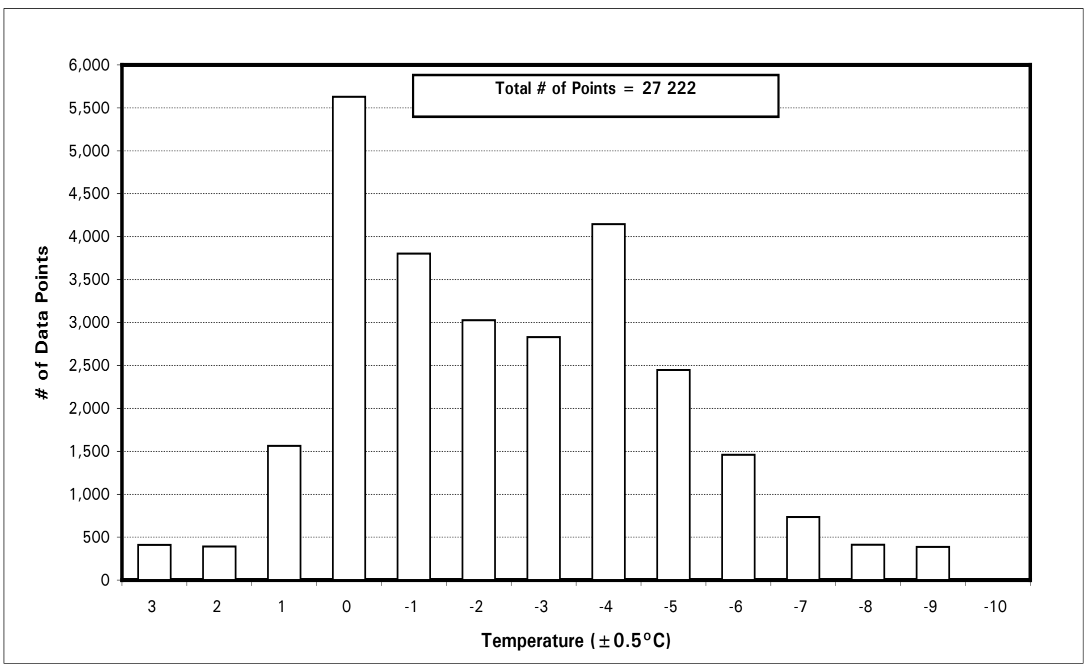

Figure 2.6: Temperature Distribution for Freezing Rain/Drizzle 1997-2005

2.2.3 Ice Pellets

As noted at the beginning of this section, APS acquired an extensive hourly observation weather information dataset from MSC. The observation period was from January 1, 1990 to December 31, 2001. This dataset is presented in more detail in Section 2.4. Among other parameters, the data contains observations with respect to the weather condition. The dataset for Montreal was analysed in an attempt to determine the frequency of occurrence of ice pellet conditions during typical winter months. As typical winter months, the months of October to April of each of the 12 years were selected. The results are presented in Table 2.10.

Table 2.10: Frequency of Occurrence of Ice Pellets between 1990 and 2001 (Montreal, Quebec)

			%
1.	Number of hourly observations under precipitation conditions	21 343	100
2.	Ice Pellet Observations (Ice Pellets and Ice Pellet Showers only)	36	0.17
3.	Combined Ice Pellet Observations (IP mixed with other precipitation types excluding the observations accounted for at point 2.)	376	1.76
		Total percent of IP precipitation	**1.93**

The information presented in Table 2.10 was gathered exclusively from the 12-year dataset of hourly observations for Montreal, and does not include the CR21X data collected and analysed in this report.

As observed in Table 2.10, it was found that the IP occurrences accounted for less than two percent of all precipitation conditions during the winter months. Also, the IP conditions occurred mostly mixed with other precipitation types, typically with freezing rain, freezing drizzle and snow. The dataset provided by MSC does not contain information with respect to which was the predominant weather condition during these mixed precipitation events. Ice pellets as a stand-alone precipitation condition constituted only about 10 percent of the total time IP conditions occurred.

From the CR21X data collected during the 2004-05 winter, 3,122 ice pellet data points were collected for Montreal and two other Quebec stations (Quebec and High Falls). These represent approximately 52 hours of ice pellet data. The ice pellet data were identified using the Monthly Summaries and the information provided on the MSC website. For three other Quebec stations (Pointe-au-Père, Rouyn and Frelighsburg), the information available online does not specify the precipitation type and, as a result, these three stations were not included in the analysis. The distribution of the data by temperature is shown in Figure 2.7.

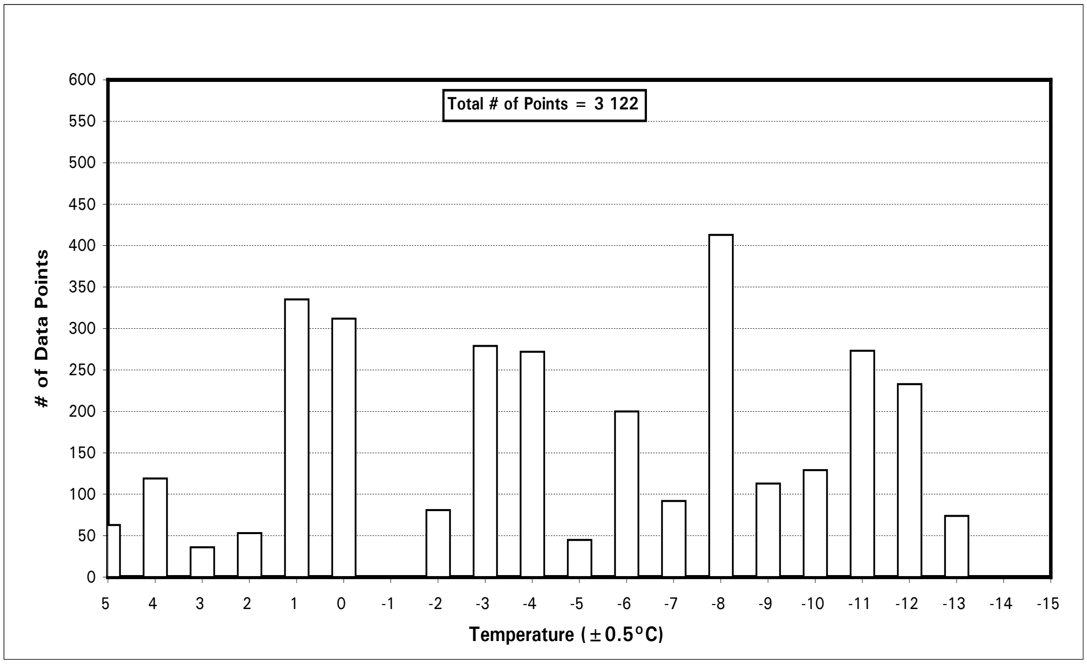

Figure 2.7: Temperature Distribution for 2004-05 – Ice Pellets

Similar to the situation illustrated in Table 2.10, the ice pellet conditions occurred mostly mixed with other precipitation types. Periods of low-rate ice pellet precipitation might have been overlooked due to long interruptions in bucket weight changes. Also, it was established as a procedure that ice pellet precipitation conditions with duration of less than 2 hours be excluded.

The distribution of the 2004-05 data points by temperature range is listed in Table 2.11.

Table 2.11: Distribution of 2004-05 Ice Pellet Data Points by Temperature

Temperature Range	# of Data Points
Above 0ºC	918
Between 0 and -10°C	1 576
Below -10°C	628
Total	**3 122**

2.2.4 Validity of Gauges for Recording Precipitation Data

The objective of this section is to evaluate and compare precipitation rates measured with the automated gauge used for this study to the plate pans used for measuring rates for endurance times.

Figure 2.8 shows a comparison of precipitation rates of the READAC gauge and the plate pans (described below) for a storm on January 15, 1999. Figure 2.9 illustrates another comparison during the same storm, this time using the CR21X gauge.

Figure 2.8 and Figure 2.9 show the precipitation rate over a 24-hour period. The 6-minute moving average rates calculated from the CR21X data show much more detail than the READAC. Higher rates were detected from this station because the smoothed data from the lower-resolution READAC station does not allow detection of rapid increases and decreases in rates.

Plate pan data collected from the APS test site located at Trudeau Airport are included in Figure 2.8 and Figure 2.9. The pans were placed at a 10º angle on test stands approximately 30 m away from the precipitation gauge. The rates from the pans are based on the weight of snow that collected in the pans during 10-minute periods. The rates were recorded at the end of each time interval, and each value is based on the average of the two simultaneous pan measurements.

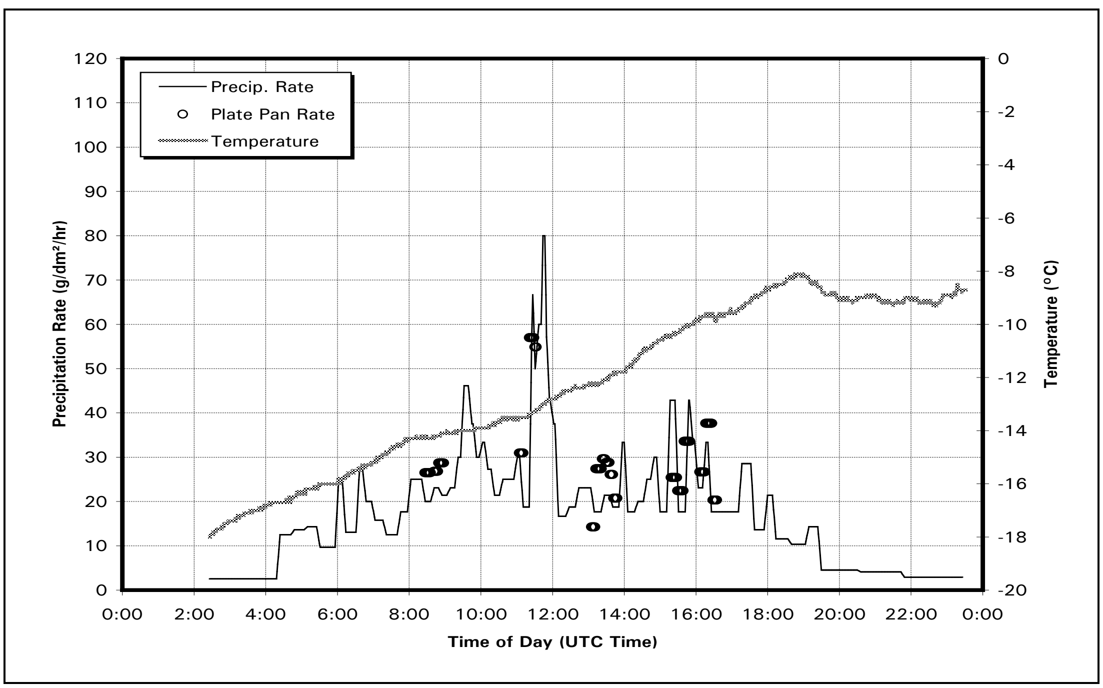

Figure 2.8: READAC Precipitation Rate, January 15, 1999

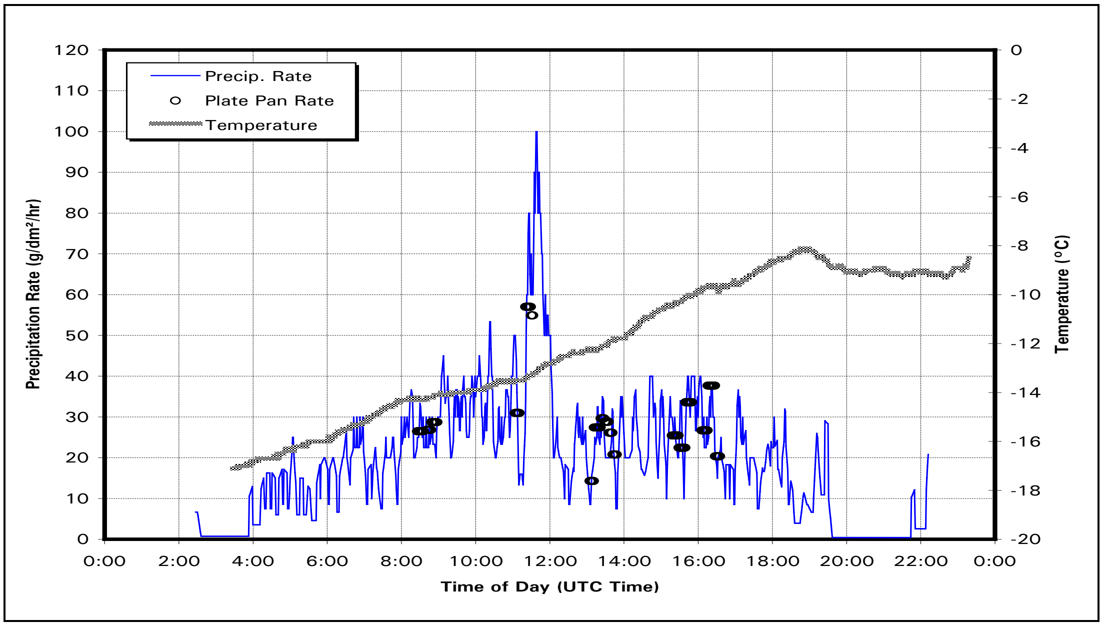

Figure 2.9: CR21X Precipitation Rate, January 15, 1999

Furthermore, because of questions raised by MSC concerning the accuracy of precipitation gauges, a new analysis has been performed on the 2000-01 winter data. Following the same methodology, the CR21X gauge data were plotted against the plate pan data collected by APS at Trudeau Airport on January 11, 2001. The results are presented in Figure 2.10. At least one verification should be made annually by comparing the rates obtained from the precipitation gauges and the plate pans.

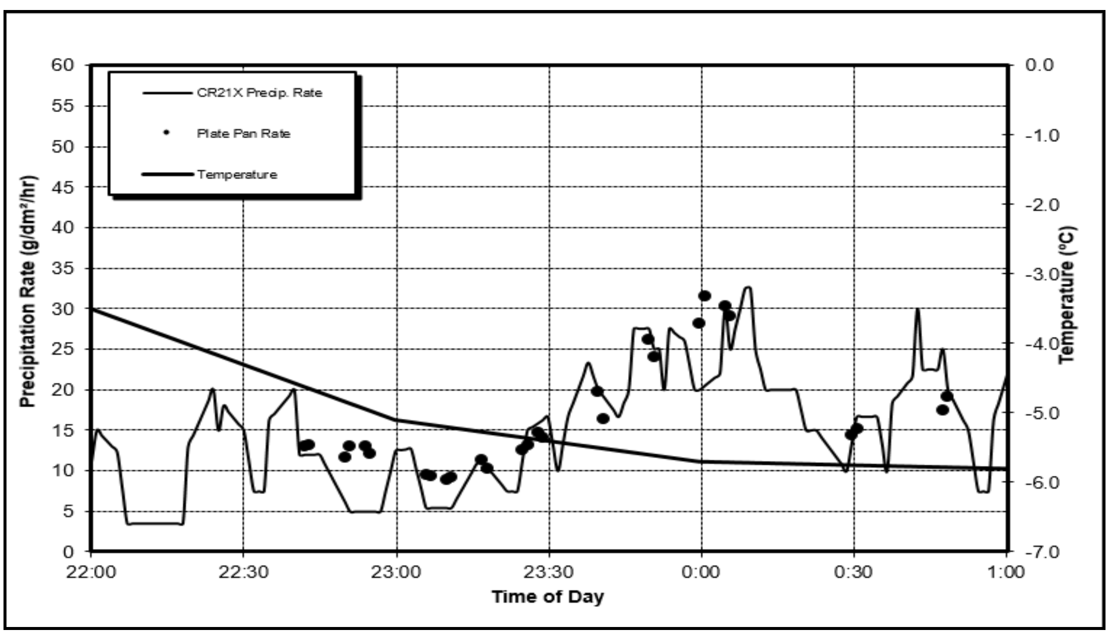

Figure 2.10: CR21X Precipitation Rate, January 11, 2001

For the 2002-03 winter, the recorded snow event took place on February 22, 2003. The results are presented in Figure 2.11. As can be seen, the data points from the plate pans correlate well with the traces shown in Figure 2.11.

For the 2003-04 winter, the recorded snow event took place on February 22, 2003. The results are presented in Figure 2.12, and as shown, the data points from the plate pans correlate well with the traces.

A similar analysis was conducted for the 2004-05 winter season. For the 2004-05 winter, the recorded snow event took place on January 6, 2005. The results are presented in Figure 2.13.

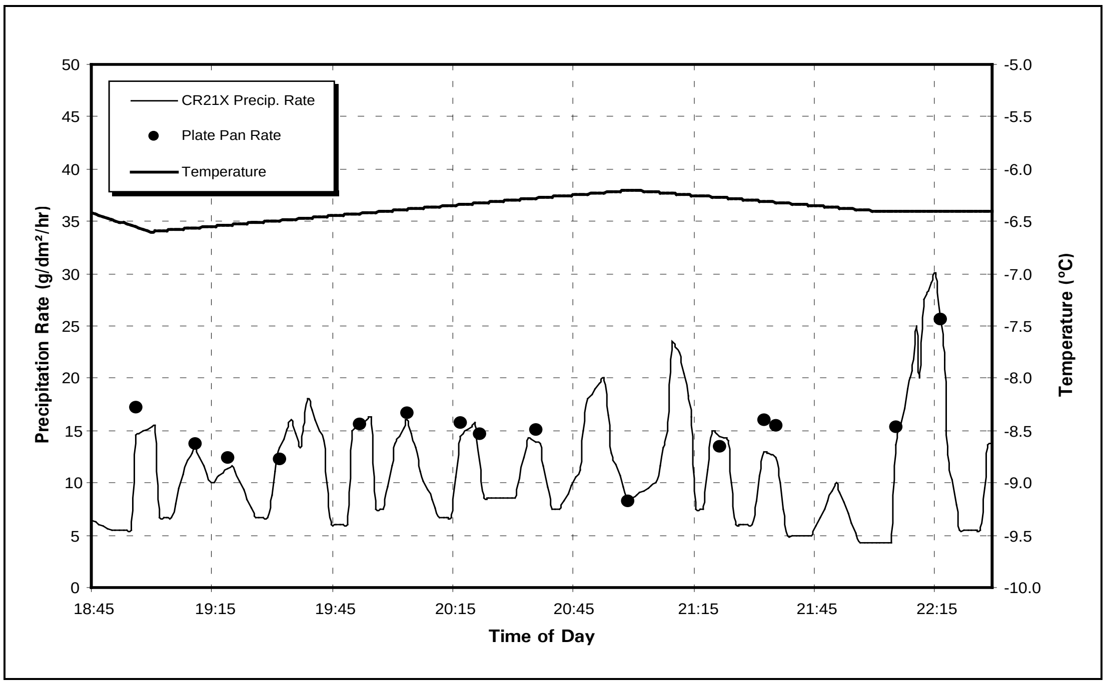

Figure 2.11: CR21X Precipitation Rate, February 22, 2003

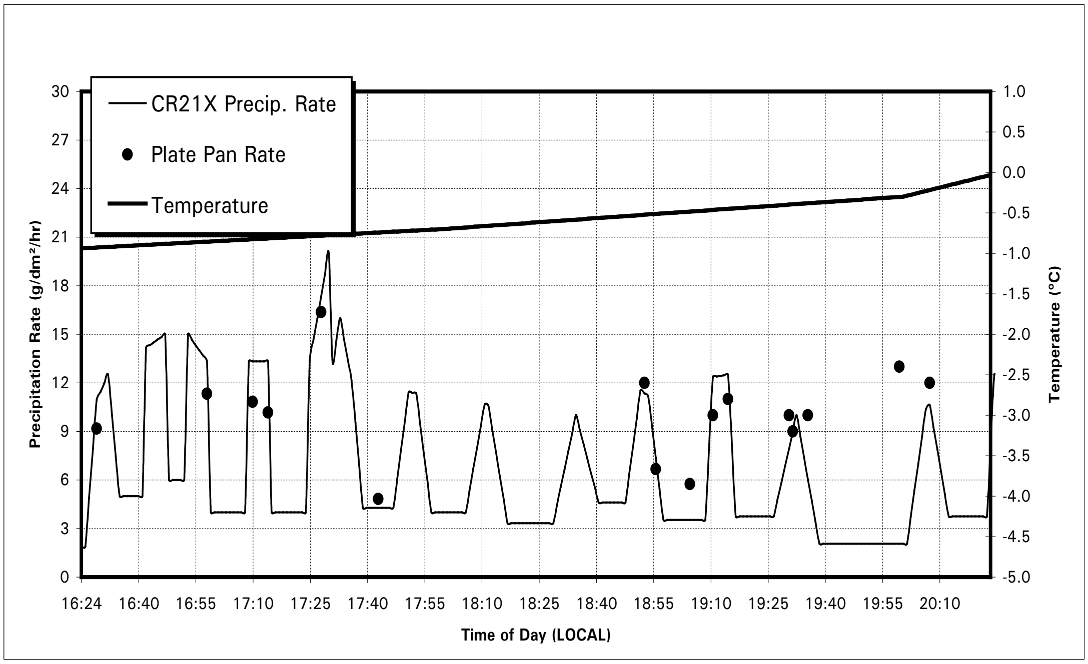

Figure 2.12: CR21X Precipitation Rate, March 20, 2004

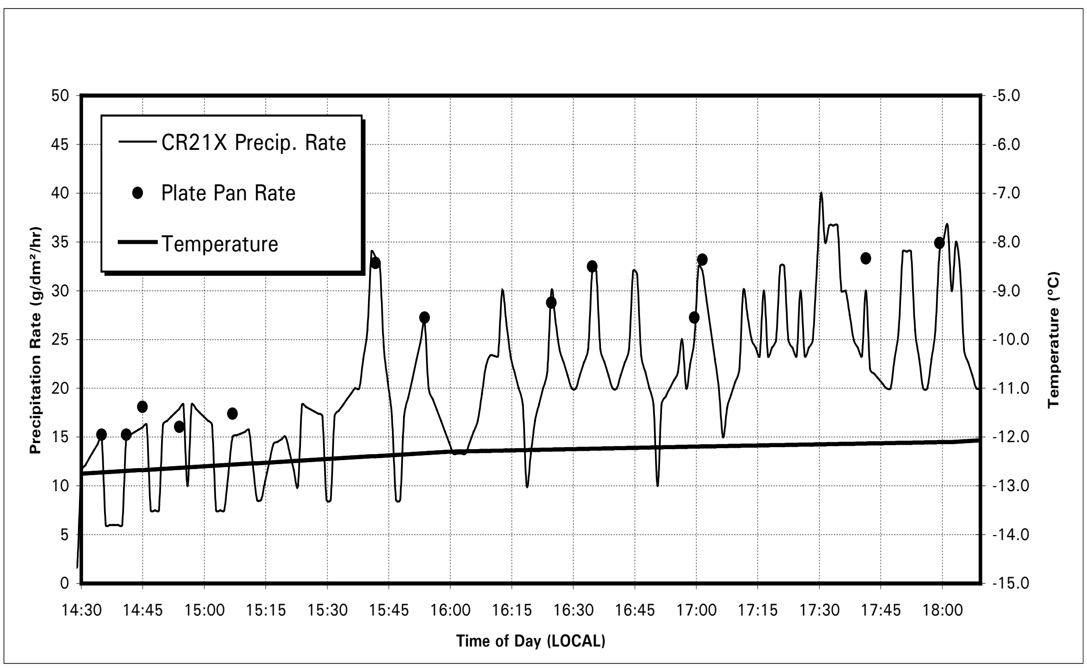

Figure 2.13: CR21X Precipitation Rate, January 6, 2005

As shown in Figure 2.13, the data points from the plate pans correlate well with the traces. During the snowstorm presented in Figure 2.13, the wind speed recorded was around 30 km/h. More precipitation accumulates in rate pans during high winds because the collection pans are facing into the wind. The small differences between the precipitation gauge trace and the plate pan points could be due to the 10º angle of the test stand. Even so, the CR21X results are close enough to those of the collection pans that they can be used to analyse the precipitation data.

2.3 Analysis and Observations for Natural Snow, Freezing Rain/Drizzle and Ice Pellets

Precipitation rates were calculated from the weather data on a minute-by-minute basis using a moving average based on 6-, 20-, and 35-minute intervals. Table 2.12 shows minute-by-minute READAC data at Trudeau Airport for a 49-minute period on December 14, 1995. Also shown are the 6-minute, 20-minute, and 35-minute averages computed using the linearized accumulation. The average snow rates, used as data points, were calculated by taking the snow accumulation during a specific time interval and dividing it by the interval. The three intervals used for this analysis are represented by brackets in the column next to "Linearized Total Snow Accumulation" in Table 2.12. The average snow rate was recalculated every minute by moving the brackets down at one-minute intervals.

For each interval, the rate is calculated every minute using the following method:

$$Rate_i = \frac{W_i - W_{i-1}}{\Delta time}$$

Where:

$Rate_i$	is the rate at a given time;
W_i	is the linearized bucket weight at that time;
W_{i-1}	is the linearized bucket weight at a one-time interval before the given time; and
$\Delta time$	is the length of the time interval (6, 20, or 35 minutes).

A temperature was associated with the rate, based on the time and day at which the rate was measured. All rate and temperature data were added to a database that contained calculated precipitation rates classified by ambient temperature for all sites included in the study. The database was then sorted by temperature range (*above 0°C*, *0 to -3°C*, *-3 to -14°C*, and *-14 to -25°C*) and the probability for each precipitation rate at each temperature range was calculated using histograms and cumulative percentages.

The snow weather data were graphed in two formats. In one format, the number of snow precipitation events was plotted against the precipitation rates (Figure 2.14). The other format (Figure 2.15) plots the cumulative probability of snow over all possible precipitation rates. The figures shown correspond to the temperature range of -3 to -7ºC for 20-minute rate calculations. Both plots used the corresponding period to calculate average precipitation rates.

The histogram in Figure 2.14 indicates that snow events with low precipitation rates occurred much more frequently than those with high precipitation rates for the temperature range shown.

The cumulative probability in Figure 2.15 indicates that over 97 percent of all the natural snow events in the data had precipitation rates below 25 $g/dm^2/h$ for 20-minute rate intervals.

A complete set of plots for all temperature ranges and rate durations for natural snow and freezing rain/drizzle is included in Appendix B. As mentioned earlier, this report encompasses all the data presented in TC report, TP 14375E, *Winter Weather Impact on Holdover Time Table Format (1995-2004)*, (1). For consistency purposes, the data in Appendix B is presented using the same temperature ranges used in the previous versions of this report. Moreover, changing the temperature breakdowns to reflect the values in the TC HOT table for Type I fluids (i.e. change -7°C to -6°C), does not produce a major change in the charts. These temperature ranges will also be used in the remainder of this section.

2.3.1 Natural Snow

This analysis takes into account the snow data set from the last ten winters – the 1995-96 winter to the 2004-05 winter.

The 95th percentiles for several temperature ranges for natural snow conditions are shown in Table 2.13.

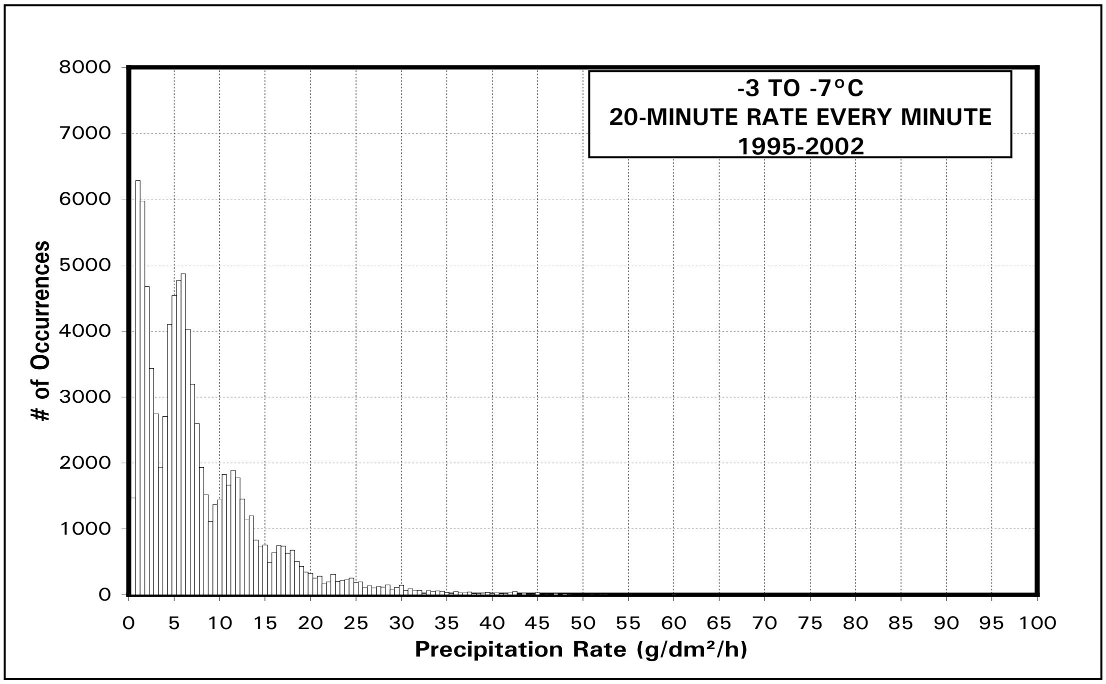

Figure 2.14: READAC and CR21X Analysis – Natural Snow Histogram

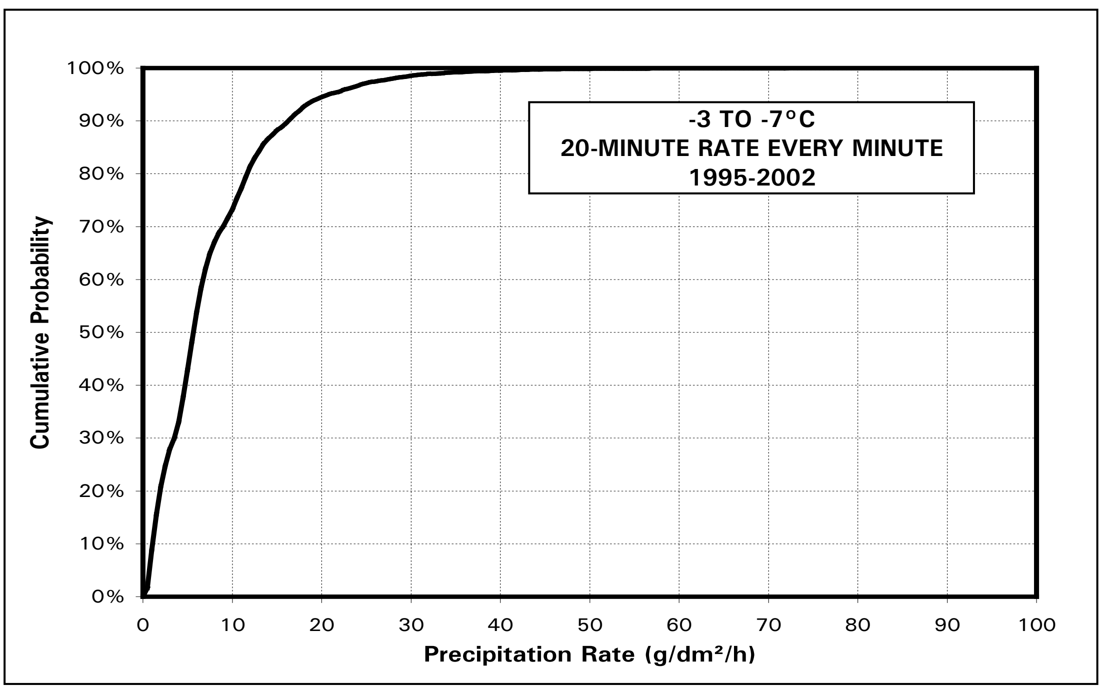

Figure 2.15: READAC and CR21X Analysis – Natural Snow Cumulative Probability

Table 2.12: Sample READAC Data and Analysis

Location	Date	UTC Time	Temp (°C)	Type of Precip.	Total Snow Accumulation (g/dm²)	Linearized Total Snow Accumulation (g/dm²)		Precipitation Rate (g/dm²/h) Moving Average Intervals 6 min	20 min	35 min
YUL	14/12/1995	21:16	-11.8	S-	40	40.00		(a)	(b)	(c)
YUL	14/12/1995	21:17	-11.7	S-	40	40.16		9.38	[illegible]	[illegible]
YUL	14/12/1995	21:18	-11.6	S-	40	40.31		9.38	[illegible]	[illegible]
YUL	14/12/1995	21:19	-11.6	S-	40	40.47		9.38	[illegible]	[illegible]
YUL	14/12/1995	21:20	-11.6	S-	40	40.63		9.38	[illegible]	[illegible]
YUL	14/12/1995	21:21	-11.6	S-	40	40.78		9.38	[illegible]	[illegible]
YUL	14/12/1995	21:22	-11.6	S-	40	40.94		9.38	[illegible]	[illegible]
YUL	14/12/1995	21:23	-11.5	S-	40	41.09		9.38	[illegible]	[illegible]
YUL	14/12/1995	21:24	-11.6	S-	40	41.25		9.38	[illegible]	[illegible]
YUL	14/12/1995	21:25	-11.6	S-	40	41.41		9.38	9.38	[illegible]
YUL	14/12/1995	21:26	-11.4	S-	40	41.56		9.38	9.38	[illegible]
YUL	14/12/1995	21:27	-11.4	S-	40	41.72		[illegible]	9.38	[illegible]
YUL	14/12/1995	21:28	-11.5	S-	40	41.88		9.38	9.38	[illegible]
YUL	14/12/1995	21:29	-11.5	S-	40	42.03		9.38	9.79	13.16
YUL	14/12/1995	21:30	-11.4	S-	40	42.19		9.38	10.20	13.39
YUL	14/12/1995	21:31	-11.4	S-	40	42.34		9.38	10.62	13.48
YUL	14/12/1995	21:32	-11.4	S-	40	42.50		9.38	11.03	13.57
YUL	14/12/1995	21:33	-11.4	S-	40	42.66		9.38	[illegible]	13.66
YUL	14/12/1995	21:34	-11.4	S-	40	42.81		9.38	[illegible]	13.75
YUL	14/12/1995	21:35	-11.4	S-	40	42.97		[illegible]	12.27	13.84
YUL	14/12/1995	21:36	-11.3	S-	40	43.13		9.38	12.68	13.93
YUL	14/12/1995	21:37	-11.3	S-	40	43.28		9.38	13.10	14.02
YUL	14/12/1995	21:38	-11.4	S-	40	43.44		9.38	13.51	14.11
YUL	14/12/1995	21:39	-11.4	S-	40	43.59		9.38	13.92	14.20
YUL	14/12/1995	21:40	-11.3	S-	40	43.75		9.38	14.34	14.29
YUL	14/12/1995	21:41	-11.3	S-	40	43.91		9.38	14.75	14.38
YUL	14/12/1995	21:42	-11.3	S-	40	44.06		9.38	15.17	14.46
YUL	14/12/1995	21:43	-11.3	S-	40	44.22		10.75	15.58	14.55
YUL	14/12/1995	21:44	-11.2	S-	40	44.38		12.13	15.99	14.64
YUL	14/12/1995	21:45	-11.2	S-	40	44.53		13.51	16.41	14.73
YUL	14/12/1995	21:46	-11.2	S-	40	44.69		14.89	16.56	14.82
YUL	14/12/1995	21:47	-11.2	S-	40	44.84		16.27	16.72	14.91
YUL	14/12/1995	21:48	-11.2	S-	45	45.00		17.65	16.88	15.00
YUL	14/12/1995	21:49	-11.2	S-	45	45.29		17.65	16.62	14.85
YUL	14/12/1995	21:50	-11.2	S-	45	45.59		17.65	16.36	14.71
YUL	14/12/1995	21:51	-11.2	S-	45	45.88		17.65	16.10	14.56
YUL	14/12/1995	21:52	-11.1	S-	45	46.18		17.65	15.85	14.41
YUL	14/12/1995	21:53	-11.1	S-	45	46.47		17.65	15.59	14.26
YUL	14/12/1995	21:54	-11.1	S-	45	46.76		17.65	15.33	14.12
YUL	14/12/1995	21:55	-11.1	S-	45	47.06		17.65	15.07	14.18
YUL	14/12/1995	21:56	-11.1	S-	45	47.35		17.65	14.82	14.25
YUL	14/12/1995	21:57	-11.1	S-	45	47.65		17.65	14.56	14.32
YUL	14/12/1995	21:58	-11.1	S-	45	47.94		17.65	14.30	14.39
YUL	14/12/1995	21:59	-11.0	S-	45	48.24		17.65	14.04	14.45
YUL	14/12/1995	22:00	-11.0	S-	45	48.53		16.79	13.79	14.52
YUL	14/12/1995	22:01	-11.0	S-	45	48.82		15.93	13.53	14.59
YUL	14/12/1995	22:02	-11.0	S-	45	49.12		15.07	13.27	14.66
YUL	14/12/1995	22:03	-11.0	S-	45	49.41		14.22	13.01	14.72
YUL	14/12/1995	22:04	-10.9	S-	45	49.71		13.36	12.76	14.79
YUL	14/12/1995	22:05	-10.8	S-	50	50.00		12.50	12.50	14.86

(a) = (40.94 - 40.00)*60 / 6
(b) = (43.13 - 40.00)*60 / 20
(a) = (45.88 - 40.00)*60 / 35

Table 2.13: 95th Percentile in Each Temperature Range – Natural Snow

Temperature Range	95th Percentile Precipitation Rate (g/dm²/h)		
	6 min	20 min	35 min
Above 0°C	20	20	20
0°C to -3°C	21	20	20
-3°C to -7°C	21	20	20
-7°C to -14°C	22	22	22
-14°C to -25°C	19	18	19

Each of the rates in this table represents the rate below which 95 percent of all snowfalls occurred in a specific temperature range for a given rate duration. For example, in the temperature range of *-3 to -7ºC* for a duration of 20 minutes, the 95th percentile is 20 g/dm^2/h. This indicates that 95 percent of the 20-minute rates recorded between *-3ºC to -7ºC* were equal to or below 20 g/dm^2/h. Table 2.14 shows the percent of occurrences for precipitation rates above 25 g/dm^2/h for all temperature ranges.

Table 2.14: Percentage of Heavy Snow Occurrences in Each Temperature Range, Natural Snow

Temperature Range	Percent of Occurrences when Rate is above 25 g/dm^2/h		
	6 min	20 min	35 min
Above 0°C	2.5%	2.5%	2.5%
0°C to -3°C	3.0%	2.8%	2.6%
-3°C to -7°C	2.9%	2.6%	2.4%
-7°C to -14°C	3.5%	3.6%	3.7%
-14°C to -25°C	1.7%	1.6%	1.7%

The analysis of the 6-minute snow data over the past ten winter seasons, shows that overall, about 3 percent of all snowstorm events occur at precipitation rates greater than 25 g/dm²/h, as illustrated in Figure 2.16.

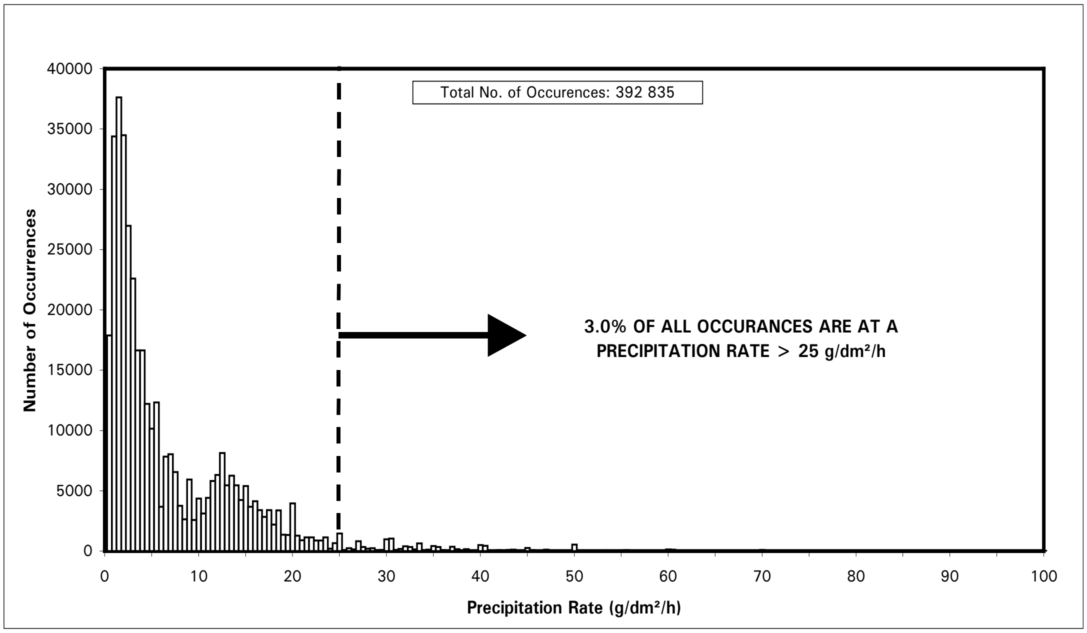

Figure 2.16: Snow Analysis at High Precipitation Rates

2.3.2 Natural Snow at Cold Temperatures

The general shape of the curve for the cumulative probability of occurrence at colder temperatures is similar to that of the curves drawn for other temperatures, as shown in Figure 2.17. The chart shows that high precipitation rates occur equally at all temperature breakdowns.

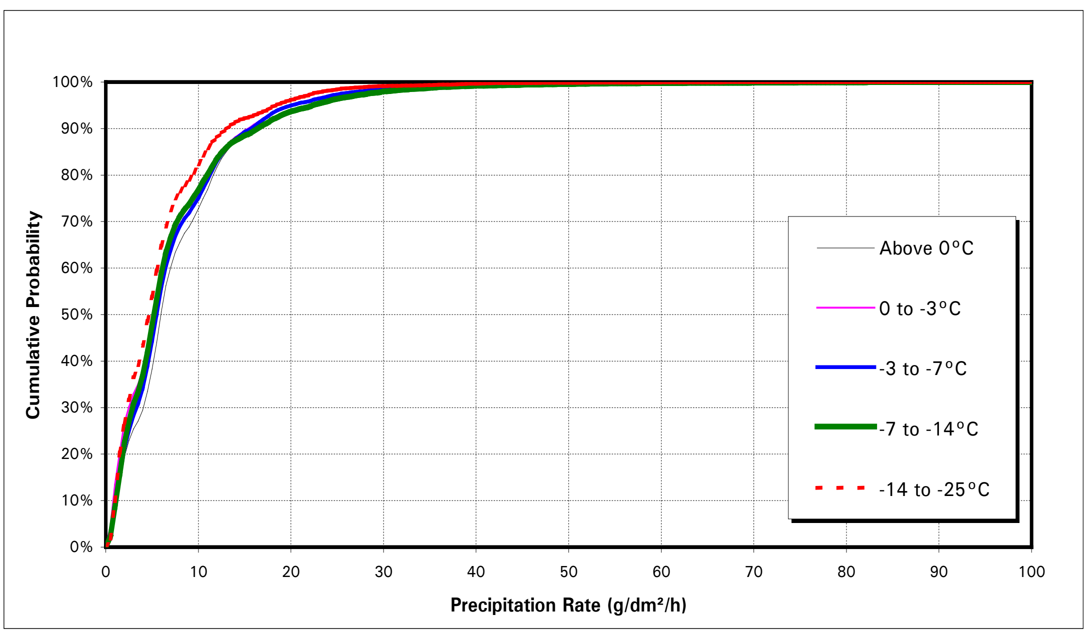

Figure 2.17: 20-Minute Rate Every Minute, All Temperature Ranges

The coldest temperature interval was divided into three smaller intervals (the data are shown in Appendix B):

a) -14 to -18°C;
b) -18 to -22°C; and
c) -22 to -25°C.

High precipitation rates were more common in the *-14 to -18°C* range, but a few high-rate snowfalls were recorded in the other two ranges, as seen in Figure 2.18.

Based on these results, consideration should be given to reformatting the HOT tables by dividing the *-14 to -25°C* interval, as precipitation rates were significantly lower at temperatures below -18°C and occurrences less frequent. However, the number of potential deicing operations at these lower temperatures needs to be considered.

For each cold temperature interval the percentage of occurrences when the precipitation rates were above 25 g/dm^2/h is shown in Table 2.15.

Table 2.15: Percentage of Heavy Snow Occurrences In Cold Temperatures – Natural Snow

Temperature Range	Percent of Occurrences when Rate is above 25 g/dm^2/h	Percent of -14 to -25°C Data Points in Each Temperature Range	Percent of Total Data Points in Each Temperature Range
-14 to -18°C	2.3%	63.6%	3.5%
-18 to -22°C	0.7%	31.3%	1.7%
-22 to -25°C	0.9%	5.1%	0.3%
	Total	**100%**	**5.5%**

2.3.3 Probability of Snow Events for Holdover Time Table Temperature Ranges

In an attempt to find the optimum temperature breakdowns for the HOT tables, the snow dataset (392,835 data points) was divided into 1°C intervals. In addition, each temperature range was split into precipitation rate ranges using 1 g/dm²/h increments. The results were translated into percentages to determine the probability of snow occurrence in each cell of the new table. The outcome is shown in Table 2.16.

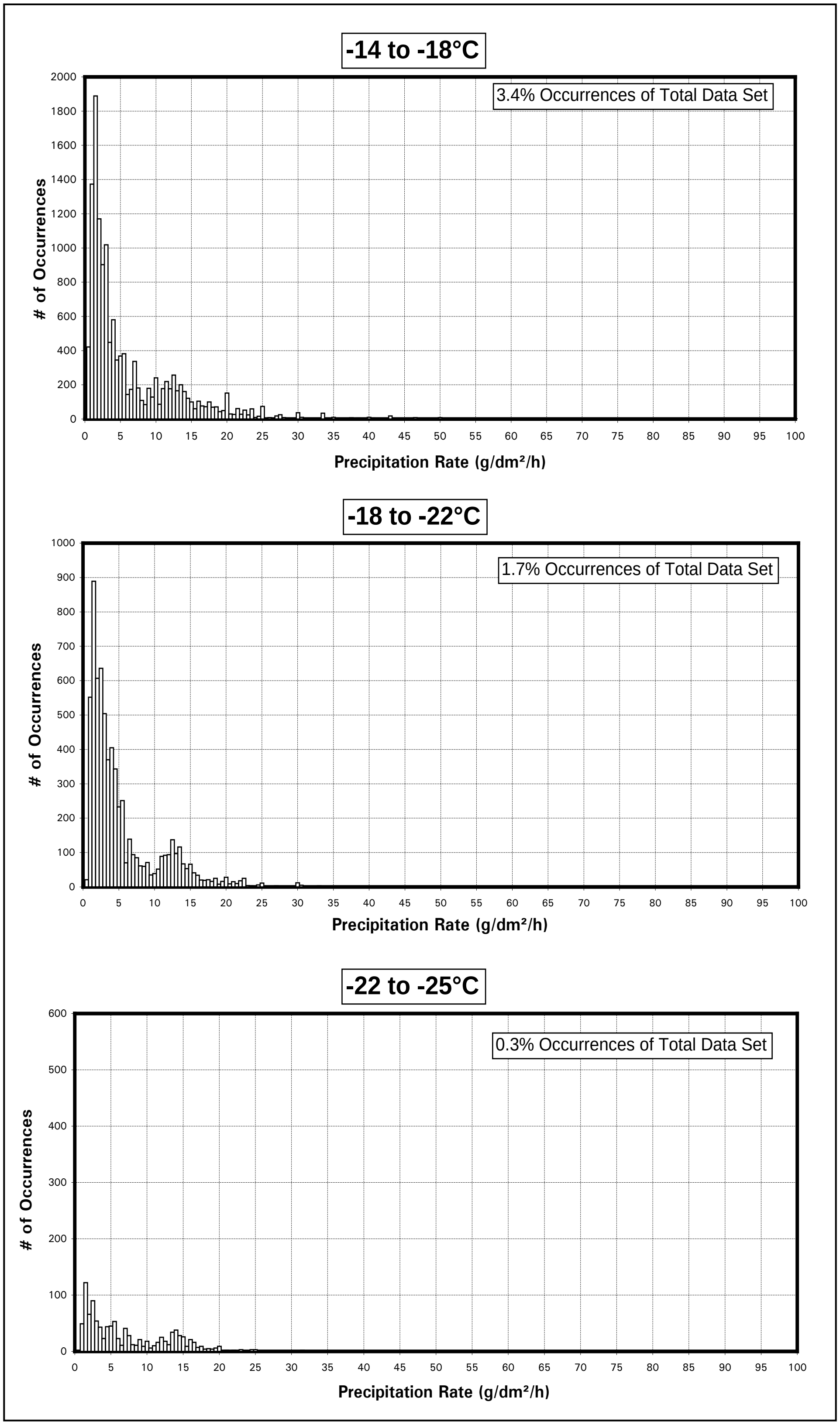

Figure 2.18: Subdivision of -14 to -25°C – Snow Data

Table 2.16: Probability (%) of Natural Snow Occurrence – 1995-96 to 2004-05 (Quebec)

TEMP (°C)	RATE OF PRECIPITATION (g/dm²/h)																											
	0 to 1	1 to 2	2 to 3	3 to 4	4 to 5	5 to 6	6 to 7	7 to 8	8 to 9	9 to 10	10 to 11	11 to 12	12 to 13	13 to 14	14 to 15	15 to 16	16 to 17	17 to 18	18 to 19	19 to 20	20 to 21	21 to 22	22 to 23	23 to 24	24 to 25	>25	Total	Cumulative
above 0	1.48	1.92	1.39	0.97	0.63	0.53	0.47	0.35	0.27	0.20	0.23	0.36	0.47	0.41	0.35	0.30	0.22	0.20	0.17	0.19	0.07	0.07	0.06	0.05	0.06	0.30	11.7	11.7
0 to -1	1.11	1.73	1.05	0.74	0.47	0.33	0.30	0.20	0.18	0.14	0.17	0.26	0.33	0.28	0.25	0.19	0.15	0.14	0.10	0.09	0.04	0.04	0.03	0.02	0.03	0.20	8.6	20.3
-1 to -2	1.57	1.40	0.92	0.60	0.50	0.34	0.38	0.22	0.21	0.15	0.17	0.24	0.24	0.23	0.22	0.19	0.15	0.14	0.10	0.12	0.05	0.05	0.05	0.03	0.05	0.27	8.6	28.9
-2 to -3	1.14	1.74	1.08	0.88	0.58	0.38	0.43	0.27	0.22	0.16	0.18	0.26	0.34	0.33	0.24	0.20	0.16	0.15	0.14	0.12	0.06	0.06	0.05	0.03	0.06	0.34	9.6	38.5
-3 to -4	1.26	1.62	1.12	0.79	0.54	0.33	0.42	0.29	0.19	0.18	0.16	0.29	0.35	0.27	0.21	0.17	0.13	0.10	0.09	0.11	0.05	0.05	0.04	0.03	0.05	0.28	9.1	47.6
-4 to -5	0.91	1.33	1.06	0.69	0.47	0.36	0.37	0.24	0.17	0.12	0.16	0.26	0.26	0.26	0.23	0.20	0.14	0.12	0.12	0.14	0.05	0.06	0.03	0.03	0.06	0.27	8.1	55.7
-5 to -6	1.02	1.22	0.92	0.64	0.45	0.33	0.34	0.21	0.17	0.13	0.16	0.22	0.24	0.18	0.16	0.13	0.12	0.10	0.09	0.10	0.05	0.04	0.03	0.02	0.03	0.16	7.3	62.9
-6 to -7	0.68	1.22	0.79	0.56	0.35	0.29	0.24	0.16	0.15	0.12	0.13	0.21	0.22	0.19	0.17	0.12	0.10	0.10	0.07	0.08	0.03	0.03	0.03	0.01	0.02	0.16	6.2	69.2
-7 to -8	0.78	1.23	0.82	0.44	0.35	0.26	0.19	0.12	0.12	0.10	0.11	0.18	0.19	0.17	0.13	0.11	0.06	0.06	0.05	0.07	0.03	0.02	0.02	0.02	0.03	0.24	5.9	75.1
-8 to -9	0.60	0.81	0.67	0.43	0.28	0.20	0.19	0.12	0.09	0.09	0.11	0.17	0.18	0.15	0.12	0.09	0.08	0.07	0.05	0.05	0.02	0.03	0.01	0.01	0.02	0.12	4.7	79.8
-9 to -10	0.50	0.68	0.57	0.39	0.26	0.16	0.16	0.10	0.09	0.10	0.07	0.15	0.15	0.14	0.09	0.08	0.07	0.07	0.05	0.06	0.03	0.03	0.02	0.03	0.03	0.11	4.2	84.0
-10 to -11	0.42	0.64	0.42	0.28	0.14	0.11	0.10	0.08	0.07	0.04	0.05	0.10	0.10	0.06	0.06	0.04	0.05	0.05	0.04	0.05	0.02	0.02	0.01	0.01	0.02	0.09	3.1	87.1
-11 to -12	0.27	0.59	0.40	0.24	0.13	0.10	0.12	0.05	0.04	0.04	0.04	0.09	0.08	0.05	0.05	0.05	0.04	0.03	0.03	0.04	0.02	0.02	0.02	0.01	0.03	0.09	2.7	89.8
-12 to -13	0.42	0.49	0.37	0.24	0.12	0.09	0.08	0.05	0.06	0.04	0.04	0.08	0.07	0.08	0.05	0.04	0.03	0.04	0.03	0.04	0.01	0.02	0.02	0.02	0.02	0.11	2.7	92.5
-13 to -14	0.31	0.47	0.28	0.15	0.11	0.06	0.07	0.05	0.04	0.03	0.04	0.08	0.07	0.05	0.03	0.02	0.02	0.01	0.02	0.02	0.01	0.01	0.00	0.01	0.01	0.11	2.1	94.5
-14 to -15	0.19	0.33	0.18	0.10	0.09	0.06	0.05	0.03	0.02	0.03	0.03	0.04	0.05	0.03	0.02	0.02	0.02	0.02	0.01	0.03	0.01	0.01	0.01	0.01	0.01	0.06	1.5	96.0
-15 to -16	0.14	0.26	0.08	0.06	0.04	0.02	0.04	0.01	0.01	0.04	0.02	0.02	0.02	0.03	0.01	0.01	0.00	0.01	0.01	0.02	0.00	0.00	0.00	0.00	0.01	0.02	0.9	96.9
-16 to -17	0.16	0.10	0.06	0.02	0.02	0.02	0.02	0.01	0.01	0.03	0.01	0.02	0.02	0.02	0.01	0.00	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.6	97.5
-17 to -18	0.10	0.10	0.11	0.03	0.02	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.5	98.0
-18 to -19	0.05	0.11	0.10	0.07	0.04	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.02	0.01	0.00	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.6	98.5
-19 to -20	0.04	0.12	0.13	0.07	0.06	0.03	0.02	0.01	0.02	0.01	0.02	0.02	0.03	0.02	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.6	99.2
-20 to -21	0.09	0.10	0.02	0.03	0.03	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.3	99.5
-21 to -22	0.03	0.04	0.02	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	99.7
-22 to -23	0.03	0.04	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	99.8
-23 to -24	0.02	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	99.9
-24 to -25	0.04	0.03	0.02	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	100.0
Total	13.3	18.4	12.6	8.5	5.7	4.1	4.0	2.6	2.2	1.8	1.9	3.1	3.5	3.0	2.4	2.0	1.6	1.4	1.2	1.3	0.6	0.6	0.4	0.3	0.5	2.9		
Cumulative	13.3	31.7	44.3	52.8	58.5	62.5	66.6	69.2	71.4	73.1	75.1	78.2	81.6	84.6	87.0	89.0	90.6	92.0	93.2	94.6	95.2	95.7	96.2	96.5	97.1	100.0		

The probability of snow event occurrences in each of the HOT temperature ranges of the HOT tables is shown in Table 2.16 and in Table 2.17. Table 2.17 corresponds to the temperature ranges of Type I fluid and Table 2.18 to the ranges of Type II and Type IV fluids. These two tables are determined based on Table 2.16.

There were no data available for natural snow conditions below -25°C. In addition, each of the tables provides probability data for snowfall as a function of very light, light, moderate, and heavy snow.

For Type I fluids, 84 percent of snow events occurred above -10°C, justifying the current temperature break at -6°C. According to the Type I table categorization around 53 percent of the rates were classified as very light snow. The probability of snow events for the Type IV table are 38.5 percent in the newly introduced *-3°C and above* temperature band and 56.1 percent for the range of *-3 to -14°C*.

The analysis presented in this report is based on data collected over ten years of observation from six meteorological stations across Quebec. A similar weather information database, comprising of hourly measurements over a 12-year period for two stations (Montreal and La Grande), was used for different projects and is discussed in Subsection 2.4. It has been included in this report for documentation purposes.

Table 2.17: Probability of Snow in Each HOT Table Temperature Range - Type I Fluids

Temperature (°C)	Very Light Snow	Light Snow	Moderate Snow	Heavy Snow	Total
-3 and above	19.7%	7.9%	9.8%	1.1%	**38.5%**
below -3 to -6	12.5%	5.4%	5.9%	0.7%	**24.5%**
below -6 to -10	11.2%	4.3%	4.9%	0.6%	**21.0%**
below -10	9.3%	2.8%	3.3%	0.6%	**16.0%**
Total	**52.7%**	**20.4%**	**23.9%**	**3.0%**	**100.0%**

Table 2.18: Probability of Snow in Each HOT Table Temperature Range – Type II and Type IV Fluids

Temperature (°C)	Very Light Snow	Light Snow	Moderate Snow	Heavy Snow	Total
-3 and above	19.7%	7.9%	9.8%	1.1%	**38.5%**
below -3 to -14	29.7%	11.5%	13.1%	1.8%	**56.1%**
below -14 to -25	3.3%	1.0%	1.0%	0.1%	**5.4%**
below -25	0.0%	0.0%	0.0%	0.0%	**0.0%**
Total	**52.7%**	**20.4%**	**23.9%**	**3.0%**	**100.0%**

2.3.4 Freezing Rain/Drizzle

The 95th percentile for two temperature ranges is shown below (Table 2.19) for freezing rain/drizzle.

Table 2.19: 95th Percentile in Each Temperature Range – Freezing Rain/Drizzle

Temperature Range	95th Percentile Precipitation Rate ($g/dm^2/h$)		
	6 min	**20 min**	**35 min**
0 to -3°C	34	31	30
-3 to -10°C	26	25	25

The 6-minute 95th percentile was 26 $g/dm^2/h$ for the *-3 to -10°C* range and 34 $g/dm^2/h$ for the *0 to -3°C* range.

Using the weather dataset provided by MSC, a separate analysis was conducted for freezing rain and freezing drizzle. The freezing rain and freezing drizzle events were tracked from 1997-98 to 2002-03 using the Monthly Meteorological Data Summary provided by MSC. The analysis methodology was identical with the one described in Sections 2.1.3 and 2.1.4. Over six winters, from 1997-98 to 2002-03, 22 freezing drizzle events and 44 freezing rain events were identified.

The analysis, indicating the event durations and the temperature and precipitation rate distributions of data points per condition, was conducted and the findings were presented in Section 2.4 of TC report, TP 14375E, *Winter Weather Impact on Holdover Time Table Format (1995-2004)*, (1).

2.3.5 Ice Pellets

As presented in Section 2.2.3, during the 2004-05 winter, 3 122 data points were collected for Montreal and two other Quebec stations (Quebec and High Falls). The analysis methodology was identical with the one described in Sections 2.1.3 and 2.1.4. During the 2004-05 winter, 12 ice pellet events were identified. In total, these represent approximately 52 hours of ice pellet data. The vast majority of the ice pellet data includes ice pellets in combination with other precipitation types, typically freezing rain, freezing drizzle or snow.

Figure 2.19 illustrates the distribution of event duration for ice pellet conditions during 2004-05.

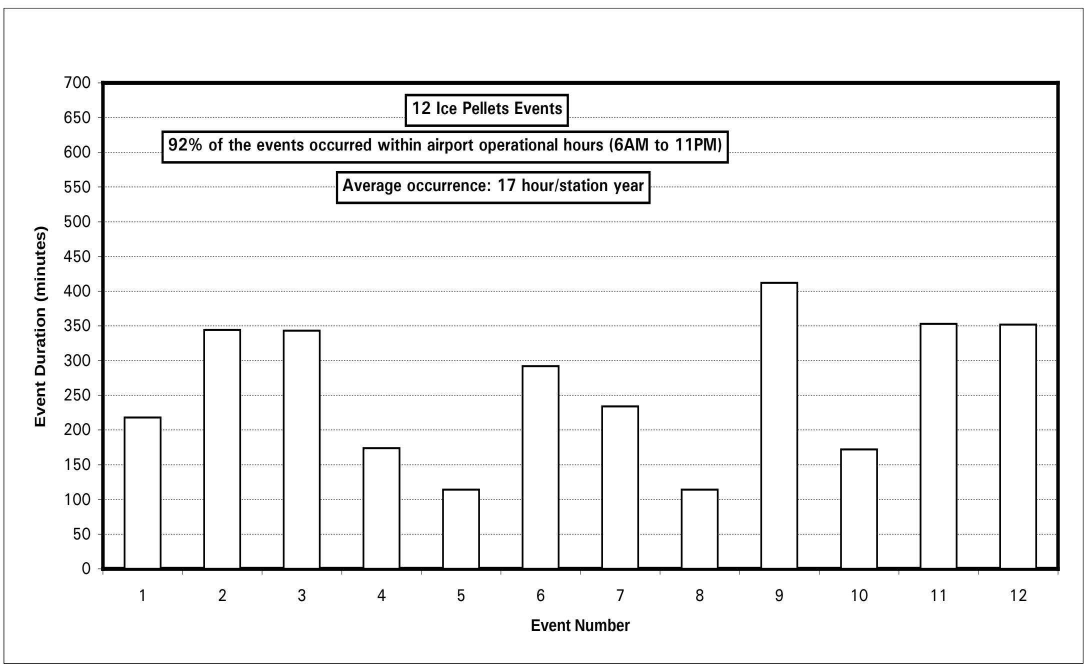

Figure 2.19: Distribution of Event Duration – Ice Pellets

Using the minute-by-minute temperature data from the CR21X file, precipitation rates were calculated and the precipitation rate distribution is presented in

Figure 2.20. Figure 2.21 plots the cumulative probability of precipitation over all possible precipitation rates.

Ninety-five percent of the 6-minute rates were equal to or below 40 g/dm^2/h. Precipitation rates above 25 g/dm^2/h represent only 11 percent of all the ice pellet occurrences.

2.4 Weather Information Database – La Grande and Montreal

An extensive dataset was acquired by APS from MSC. The hourly data contains weather observations for two meteorological stations in Quebec, located in Montreal and La Grande. The observation period is from January 1, 1990 to December 31, 2001. The data contains observations of the following parameters: visibility, wind speed, wind direction, dew point, relative humidity, atmospheric pressure, cloud opacity, cloud amount and weather condition.

This dataset of weather information was used for different projects. Initially, it was used to evaluate historical relative humidity values during conditions typical of frost, and is presented in Section 4 of TC report, TP 14145E, *Laboratory Test Parameters for Frost Endurance Time Tests* (3). The objective of that study was to examine the range of relative humidity that exists in the natural environment during periods of frost formation.

The dataset was filtered by APS by eliminating conditions that were not conducive to frost formation. The resulting database was examined for two ranges of wind - below 15 km/h and below 10 km/h.

A second application of this dataset was to assess the wind and ambient temperature distributions during natural freezing precipitation conditions, and is presented in Section 7 of TC report, TP 14144E, *Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2002-03 Winter* (4). The absence of wind appears to have a large influence on Type I fluid endurance times in freezing rain at mild ambient temperatures such as -3°C. It appears that convective heat transfer in calm conditions is unable to remove the heat derived from latent heat of freezing quickly enough to prevent the surface temperature from rising above the ambient temperature. To ascertain typical wind conditions during periods of freezing rain, weather data collected at Montreal and La Grande, Quebec were examined. It was found that about 75 percent of the freezing rain events occurred at -3°C and above, and winds of 11 km/h or above were experienced 90 percent of the time. It was concluded that such wind speeds would be expected to enhance convective heat transfer and counteract the effect of latent heat by rapidly cooling the wing to ambient temperature.

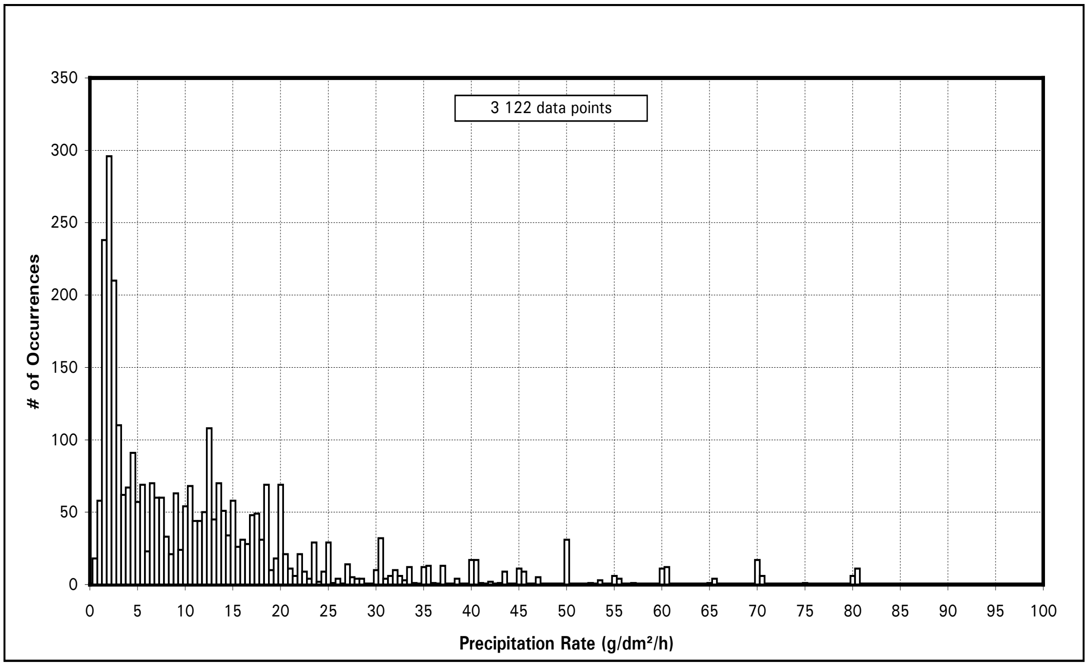

Figure 2.20: Precipitation Rate Analysis – Ice Pellets

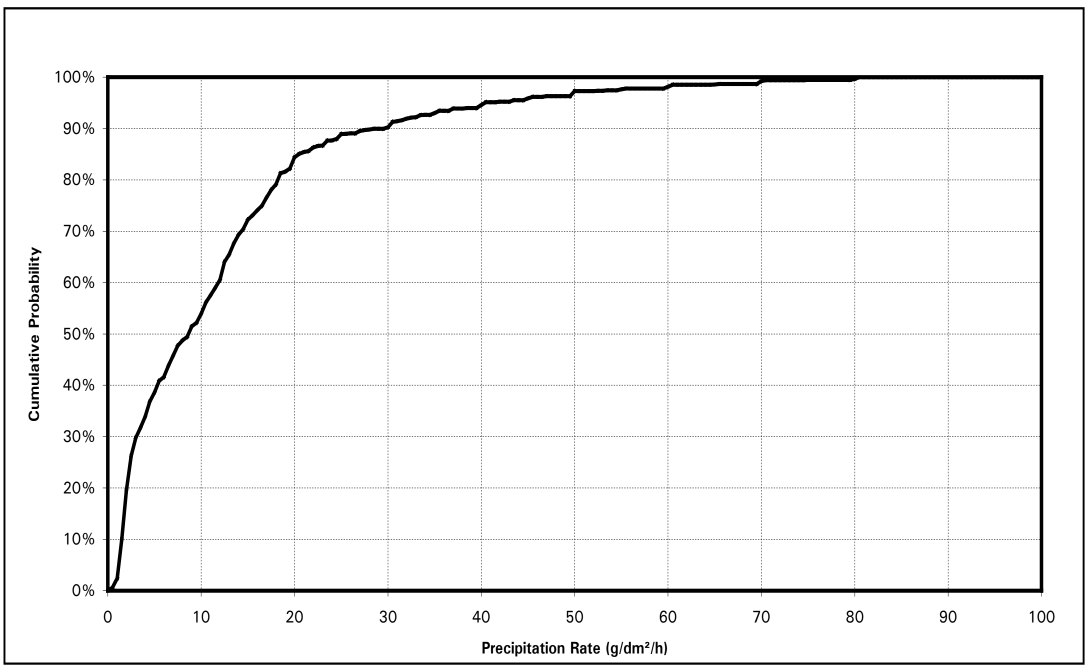

Figure 2.21: Cumulative Precipitation Rate Analysis – Ice Pellets

The dataset was also used in a study aimed at identifying the worst-case scenario for fluid evaporation (dry-out) following application in expected frost conditions. Among other parameters, the relative humidity was found to play an important role in the process. Consequently, the historical data were filtered to include only weather conditions facilitating the occurrence of frost, but under all wind speed conditions. The analysis concluded that a relative humidity of 55 to 60 percent adequately represents worst-case real world dry-out conditions, and that this range is valid for wind speeds from 0 to 20 km/h and for temperatures from +2 to -25°C. The outcome from this analysis was presented to the industry at the SAE G-12 Fluids Time Subcommittee meeting, held in Vancouver in May 2003. The presentation can be found in Appendix E of TC report TP 14155E, *Aircraft Ground Icing Research Support Activities for the 2002-03 Winter* (5).

Finally, the dataset was analysed in an attempt to determine the frequency of occurrence of ice pellet conditions during typical winter months, as presented in Section 2.2.3 of this report.

3. WINTER OPERATIONS SURVEY

Between 2000-01 and 2002-03, an annual survey was conducted by APS on behalf of TC in an attempt to collect data on actual deicing operations at several worldwide stations. TC was seeking this information in support of a review of the HOT table temperature and weather condition breakdowns such that the research and development emphasis could be aimed at conditions where an important number of operations occur worldwide. In addition, the intent was to identify where improvements could be made to the HOT table format.

To acquire a worldwide representation of deicing operations, TC distributed the survey to a number of fluid users. The combined results from the three surveys provided data for 112,535 deicing operations (Type I Table) and 86,853 anti-icing operations (Type II/IV Table). The deicing operations were sorted by weather condition: frost, freezing fog, snow, freezing drizzle, light freezing rain, and other (snow pellets, snow grain, ice pellets, rime ice). A detailed analysis of the results for each year, by weather condition, temperature and fluid type was completed and can be found in Section 3 of TC report, TP 14375E, *Winter Weather Impact on Holdover Time Table Format (1995-2004)*, (1).

Figure 3.1 demonstrates the overall results from the 2000-01, 2001-02, and 2002-03 surveys. The number of de/anti-icing operations that occurred under snow precipitation was 56 percent, thus substantiating that snow represents the most significant weather condition for deicing operations worldwide. Frost accounted for 33 percent of the deicing operations, while 7 percent was due to freezing precipitation including freezing fog, freezing drizzle, light freezing rain, and rain on cold-soak wing; and the remaining 4 percent was due to other forms of freezing precipitation (i.e. rime ice).

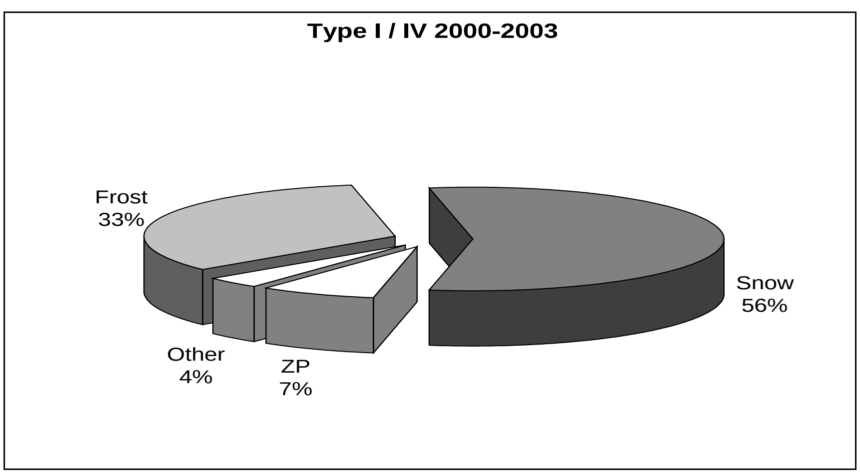

Figure 3.1: Frequency of De/Anti-icing Operations (All Airports) – Surveys 2000-01 to 2002-03

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4. CHANGES TO THE FORMAT OF THE HOLDOVER TIME TABLES

This section presents a summary of the changes done to the HOT table format over the last four years. The titles of the reports outlining these changes in more detail are in this section. Changes to the table format, agreed upon by the industry members in a certain year, are reflected in the HOT table of the following winter season.

4.1 Changes in 2001-02

In 2001-02, the Type I fluid HOT table format underwent a thorough examination. Research in previous years had indicated a need to make changes to the format. Some of the changes have been presented and accepted by the community, while others have yet to be formally accepted. The two major changes to the format of the Type I fluid HOT table were:

a) Modifying the temperature ranges of above 0°C and from 0°C to -10°C with a split point of -3°C; and
b) Addition of a column for light snow.

A detailed study providing the reasoning and justification behind those changes was conducted and could be found in Section 6 of TC report, TP 13993E, *Impact of Winter Weather on Holdover Time Table Format (1995-2002)*, (2).

4.2 Changes in 2002-03

In 2002-03 the format of the Type I tables was further reviewed and two new significant changes were implemented:

a) A new temperature breakdown was introduced by splitting the -3 to -10°C interval into below -3 to -6°C and below -6 to -10°C temperature ranges; and
b) Apart from the existing light snow and moderate snow columns, a new column for very light snow was introduced.

A detailed analysis explaining two major changes to the Type I table format was conducted and can be found in Section 4 of TC report TP 14146E, *Winter Weather Impact on Holdover Time Table Format (1995-2003)*, (6).

4.3 Changes in 2003-04

In addition to the changes described in the two aforementioned TC reports, a new Type III generic table was produced in 2003-04 and is described in Section 5 of TC report, TP 14374E, *Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2003-04 Winter* (7). Values in the new generic Type III HOT guidelines were generally based on the HOT of Clariant Safewing MP III 2031 ECO.

4.4 Changes in 2004-05

In 2004-05, there were several changes made to the format of all Type II and Type IV tables, including:

a) The *above 0ºC* temperature band was removed and incorporated within the newly modified *-3ºC and above* temperature range;

b) Viscosity information was removed from each fluid-specific table and placed in a separate viscosity table, which also includes the viscosity value measured using the Aerospace Information Report 9968 method;

c) Words previously abbreviated, including outside air temperature (OAT) and volume (vol), were replaced with their full spellings;

d) The title of the frost column was changed from "Frost" to "Active Frost";

e) The title of the snow column was changed from "Snow" to "Snow or Snow Grains";

f) The cautions section was changed so each sentence forms a new bullet; and

g) One note was modified in the generic tables and added to the fluid-specific tables to explain how the HOT values are derived.

As a result of testing with dilutions of Clariant Safewing MP III 2031 ECO, rows for 75/25 and 50/50 dilutions have been added to the Type III generic HOT guidelines. Format changes were also introduced to reflect the format changes made to the Type II/IV tables.

Some format changes were also introduced to the Type I generic HOT guidelines to reflect the format changes made to the Type II/IV tables.

4.5 Future Changes

A three-year survey of worldwide fluid users showed that the majority of the de/anti-icing operations occurred under snow precipitation, thus substantiating that snow represents the most significant weather condition for deicing operations worldwide. Table 4.1 shows the results from the survey, by weather condition and temperature range. The temperature ranges in Table 4.1 reflect the format changes implemented in the 2005-06 HOT tables. The percentage values in the table are re-calculated after the exclusion of the frost column. As can be seen in Table 4.1, in the absence of the frost column, snow accounts for over 83 percent of all deicing operations.

Table 4.1: Usage of HOT Table, Excluding Frost

OAT (°C)	FREEZING FOG	SNOW	FREEZING DRIZZLE	LIGHT FRZ. RAIN	RAIN ON COLD SOAKED WING	OTHER	Total
-3 and above	2.4%	52.8%	3.5%	2.9%	1.4%	1.3%	64.2%
-3 to -14	1.5%	28.1%	1.4%	1.2%	0.0%	1.4%	33.6%
-14 to -25	0.0%	2.2%	0.0%	0.0%	0.0%	0.0%	2.2%
below -25	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total	3.8%	83.1%	4.9%	4.1%	1.4%	2.7%	100.0%

The weather conditions in the highlighted section of Table 4.1 represent more than 87 percent of all deicing operations. In other words, the cells in the highlighted section of the table are utilised more than 87 percent of the time when deicing operations take place in precipitation conditions excluding frost. In the future, the endurance times of new deicing fluids may only be tested in these cells, as they account for the vast majority of precipitation conditions requiring deicing. The remaining cells in the table will be replaced by generic values and will be the same for all specific HOT tables.

Further discussions between the regulators and industry members are suggested to enable the development and the possible implementation of a proposed HOT table template that could be followed for future HOT testing.

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5. EVALUATION OF FROST AND FOG DEPOSITION RATES IN NATURAL CONDITIONS

This chapter contains an account of the tests conducted in the previous winter seasons to collect frost and fog deposition rates in natural conditions.

5.1 Measurement of Frost Deposition Rates in Natural Conditions

Frost deposition rate measurements were conducted during three previous test seasons. During the first two seasons, 2001-02 and 2002-03 winters, APS conducted tests to establish test parameters that reflect natural environment conditions for active frost. Rates of natural frost accretion were documented to enable specification of frost intensity for fluid endurance testing. The rates were measured using a painted white aluminum insulated plate that was found to be representative of aircraft wing surfaces.

During the last of the three seasons, 2003-04 winter, APS conducted frost endurance tests outdoors using insulated white-painted aluminum surfaces. The rates of frost accretion were documented.

The data collected during 2001-02 to 2003-04 winters, was analysed in an attempt to determine the expected icing intensities in a natural environment. A full account of the frost deposition rates that were measured during frost testing, along with the results and analysis of the data collected, can be found in Section 5 of TC report, TP 14375E, *Winter Weather Impact on Holdover Time Table Format (1995-2004),* (1).

5.2 Study to Quantify Freezing Fog Deposition Rates

Natural freezing fog deposition rate measurements were conducted during previous test seasons. It was concluded that current HOT table precipitation rate limits of 2 and 5 $g/dm^2/h$ are conservative, with rates measured during actual fog conditions being closer to 1 $g/dm^2/h$. For an account of testing from previous years, refer to TC report, TP 13993E, *Impact of Winter Weather on Holdover Time Table Format (1995-2002),* (2).

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6. CONCLUSIONS

Data gathered over ten years from six sites in Quebec form the basis for the winter weather analysis discussed in this report. The data confirms that the long-established HOT table snow precipitation rates of 10 and 25 $g/dm^2/h$ are valid limits at all temperature ranges for the *moderate snow* range. However, the data analysis also emphasizes that this range encompasses only 24 percent of all snow events, and snowfall at rates less than 10 $g/dm^2/h$ accounts for over 73 percent of all snow events. Also, snow comprises 56 percent of all deicing operations worldwide. The addition of the 2004-05 CR21X data did not significantly change the precipitation rate distribution calculated in the previous year for both natural snow and freezing rain/drizzle.

A three-year survey of worldwide fluid users showed that the percentage of deicing operations due to IP conditions is very small. However, there is a big interest in the industry for endurance time testing under ice pellet conditions, originating especially from operators that have a high volume of flights in the overnight hours.

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7. RECOMMENDATIONS

Recommendations related to specific subjects are offered.

7.1 Weather Data Survey

It is recommended that:

- This survey be continued in order to generate more data, which is particularly needed for relatively infrequent precipitation conditions such as ice pellets, freezing drizzle and freezing rain.

7.2 HOT Table Format

It is recommended that:

- A workgroup be assembled to discuss the development and the possible implementation of a proposed HOT table template that could be followed for future HOT testing.

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REFERENCES

1. Moc, N., *Winter Weather Impact on Holdover Time Table Format (1995-2004),* APS Aviation Inc., Transportation Development Centre, Montreal, December 2004, TP 14375E, XX (to be published).

2. Moc, N., Alwaid, A., *Impact of Winter Weather on Holdover Time Table Format (1995-2002)*, APS Aviation Inc., Transportation Development Centre, Montreal, December 2002, TP 13993E, XX (to be published).

3. Dawson, P., *Laboratory Test Parameters for Frost Endurance Time Tests*, APS Aviation Inc., Transportation Development Centre, Montreal, November 2003, TP 14145E, XX (to be published).

4. Bendickson, S., Campbell, R., Chaput, M., D'Avirro, J., Dawson, P., Mayodon, M., *Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2002-03 Winter,* APS Aviation Inc., Transportation Development Centre, Montreal, December 2003, TP 14144E, XX (to be published).

5. Moc, M., *Aircraft Ground Icing Research Support Activities for the 2002-03 Winter*, APS Aviation Inc., Transportation Development Centre, Montreal, September 2003, TP 14155E, XX (to be published).

6. Moc, N., *Winter Weather Impact on Holdover Time Table Format (1995-2003)*, APS Aviation Inc., Transportation Development Centre, Montreal, October 2003, TP 14146E, XX (to be published).

7. Bendickson, S., *Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2003-04 Winter*, APS Aviation Inc., Transportation Development Centre, Montreal, December 2004, TP 14374E, XX, (to be published).

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APPENDIX A

TRANSPORTATION DEVELOPMENT CENTRE
WORK STATEMENT EXCERPT
AIRCRAFT & ANTI-ICING FLUID
WINTER TESTING 2003-05

TRANSPORTATION DEVELOPMENT CENTRE
WORK STATEMENT EXCERPT
AIRCRAFT & ANTI-ICING FLUID
WINTER TESTING 2003-05

6.7 SAE Standards for Measuring Holdover Times

6.7.3 Short Term Changes to the HOT Tables Proposed by Workgroup

a) Remove the "Above 0°C" row for the Type II/III/IV HOT table guidelines; and make other editorial changes (i.e. removal of abbreviations) as identified by the HOT Working Group;

b) Develop tables of viscosities for the HOT tables, including the viscosities using the new proposed AIR method with the LV2 Spindle;

c) Develop or acquire viscosities for Clariant Type III, Clariant 1951, Kilfrost ABC-3 and also for the dilutions of all other fluids. Provide this information to FAA and TC for their consideration for inclusion in the table of viscosities;

d) Prepare presentation of all changes agreed upon by the HOT workgroup meeting and deliver at the next SAE G-12 HOT Subcommittee meeting; and

e) Develop and acquire LOUT data (aerodynamic acceptance) for the currently qualified fluids for the high and low speed ramps at the maximum dilution. Provide this information to the FAA and TC for their consideration for inclusion in the HOT guidelines.

6.10 Evaluation of Winter Weather Data

a) Collect more data from the six weather stations in Quebec, with emphasis on freezing drizzle and freezing rain;

b) Evaluate the operations survey to determine if more cities worldwide are needed to enhance the confidence in the data;

c) Analyze the data collected and report the findings; and

d) Provide any resulting recommendations that may have an impact on the HOT table format.

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APPENDIX B

WINTER WEATHER DATA 1995-96 TO 2003-04

WINTER WEATHER DATA

1995-96 TO 2003-04

The following charts include the complete rate data analysis, subdivided by temperature ranges for both snow and freezing rain. A histogram of points and a cumulative probability chart are included for each rate calculation interval in all temperature ranges.

The lowest holdover time temperature range for snow conditions (-14°C to -25°C) was subdivided into three ranges. The charts for this analysis are also included.

INDEX

SNOW

LIGHT FREEZING RAIN / DRIZZLE

COLD SNOW SUBDIVISION

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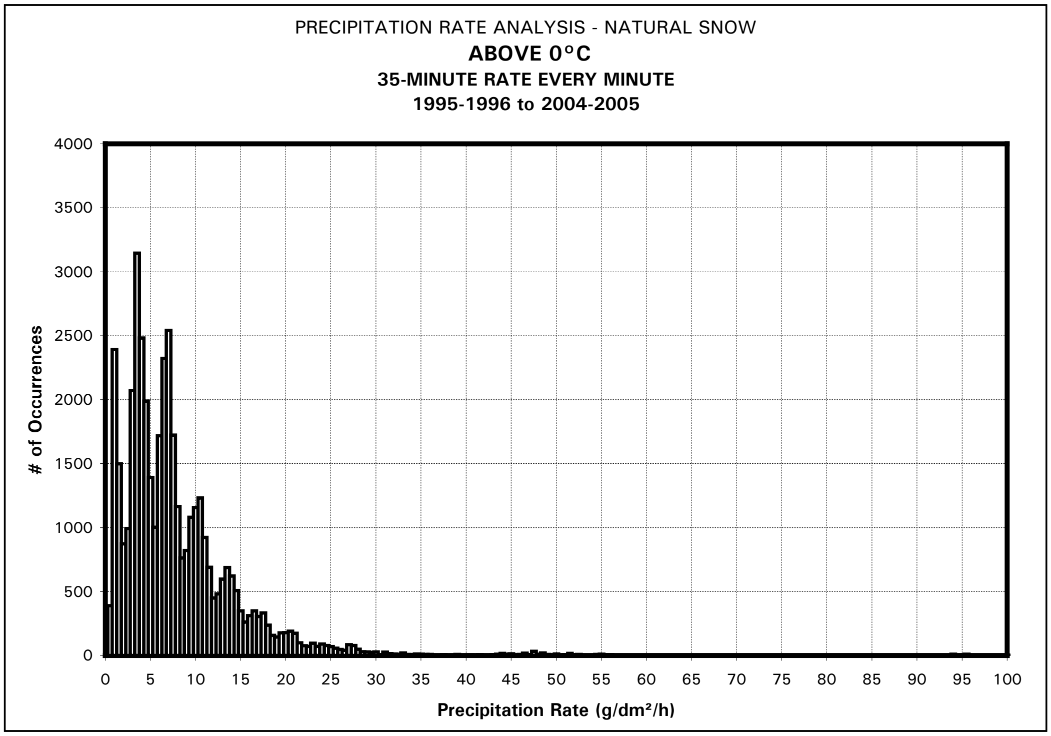
PRECIPITATION RATE ANALYSIS - NATURAL SNOW
ABOVE 0°C
35-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
# of Occurrences
0
500
1000
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2500
3000
3500
4000
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
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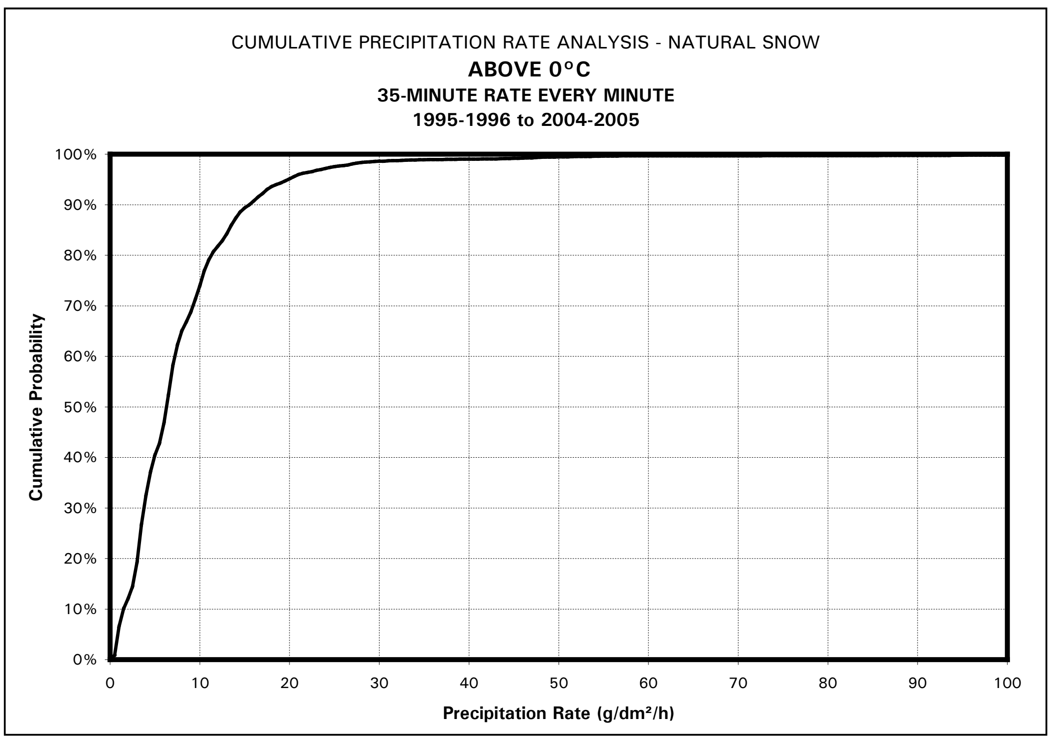
CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
ABOVE 0°C
35-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
Cumulative Probability
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
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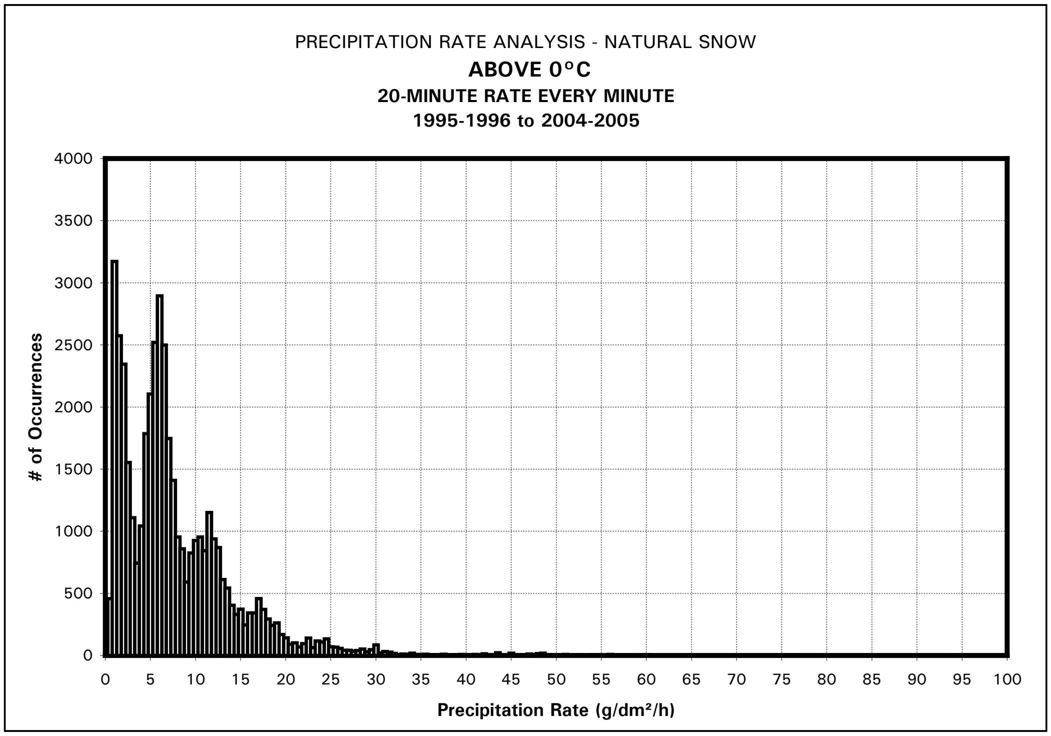
Precipitation Rate (g/dm²/h)


PRECIPITATION RATE ANALYSIS - NATURAL SNOW
ABOVE 0°C
20-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
# of Occurrences
0
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1000
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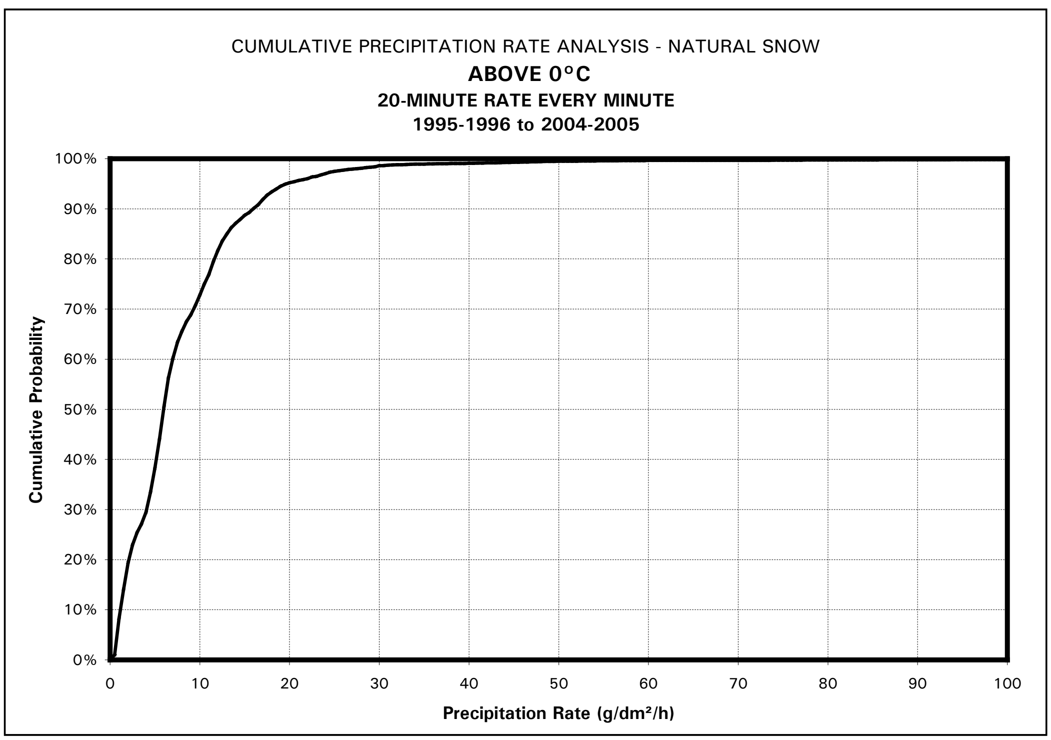
2000
2500
3000
3500
4000
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)


CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
ABOVE 0°C
20-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
Cumulative Probability
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
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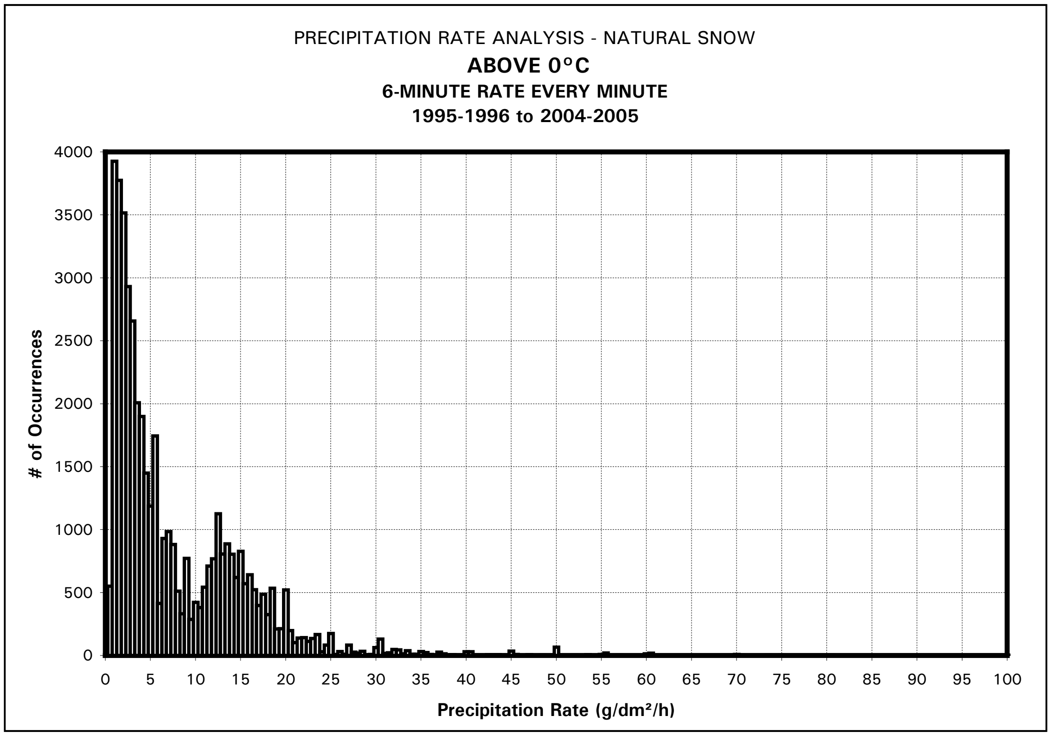
Precipitation Rate (g/dm²/h)


PRECIPITATION RATE ANALYSIS - NATURAL SNOW
ABOVE 0°C
6-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
# of Occurrences
4000
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3000
2500
2000
1500
1000
500
0
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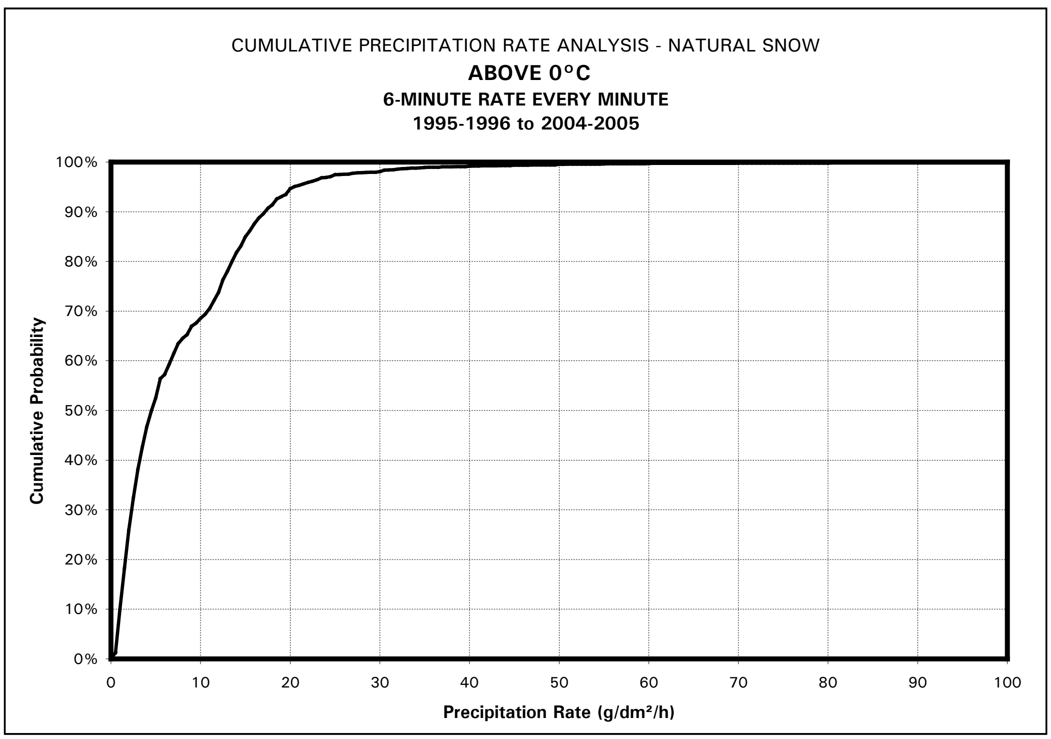
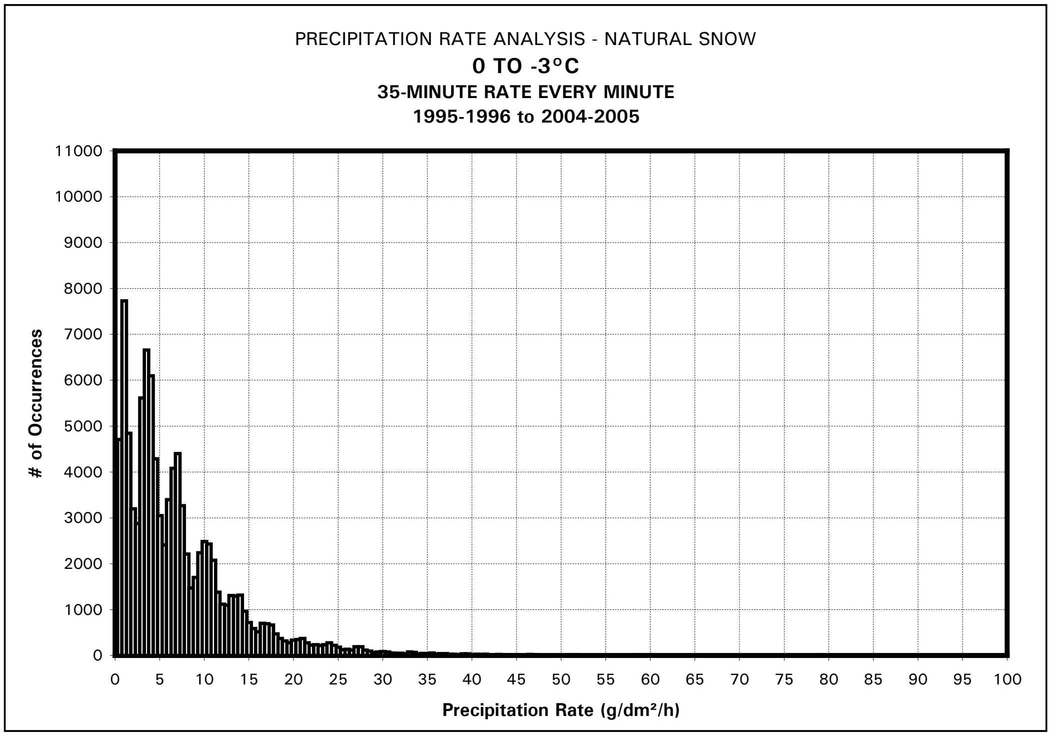
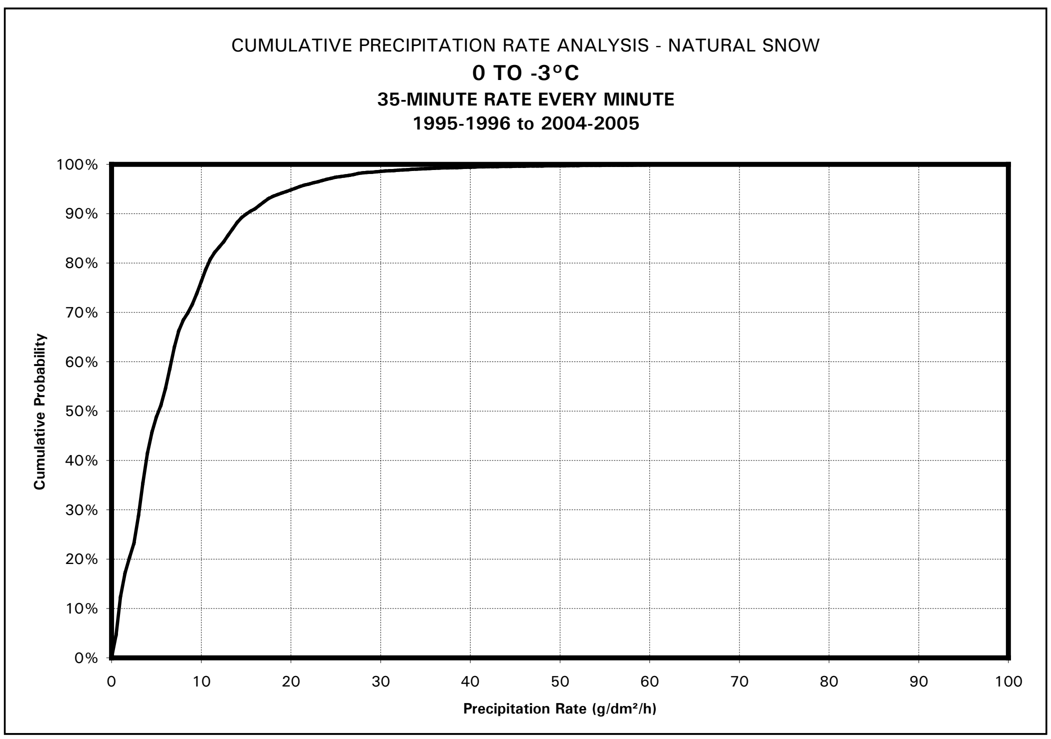
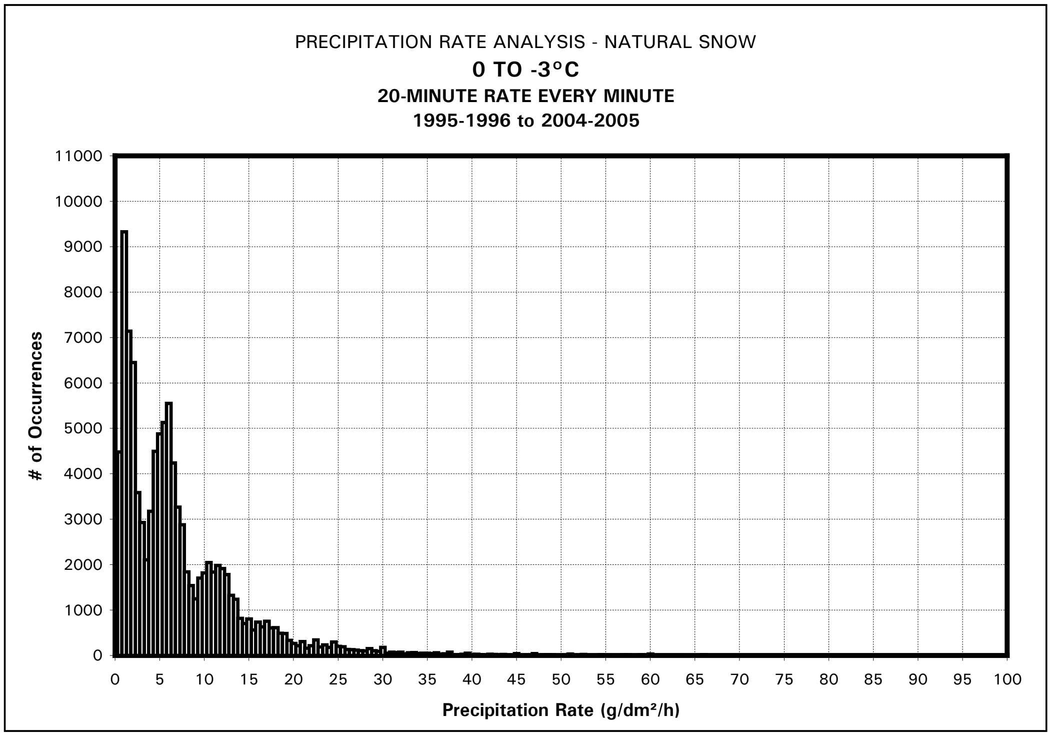
Precipitation Rate (g/dm²/h)


CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
ABOVE 0°C
6-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
Cumulative Probability
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0 10 20 30 40 50 60 70 80 90 100
Precipitation Rate (g/dm²/h)


PRECIPITATION RATE ANALYSIS - NATURAL SNOW
0 TO -3°C
35-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
# of Occurrences
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)


CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
0 TO -3°C
35-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
Cumulative Probability
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
0 10 20 30 40 50 60 70 80 90 100
Precipitation Rate (g/dm²/h)


PRECIPITATION RATE ANALYSIS - NATURAL SNOW
0 TO -3°C
20-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
# of Occurrences
0
1000
2000
3000
4000
5000
6000
7000
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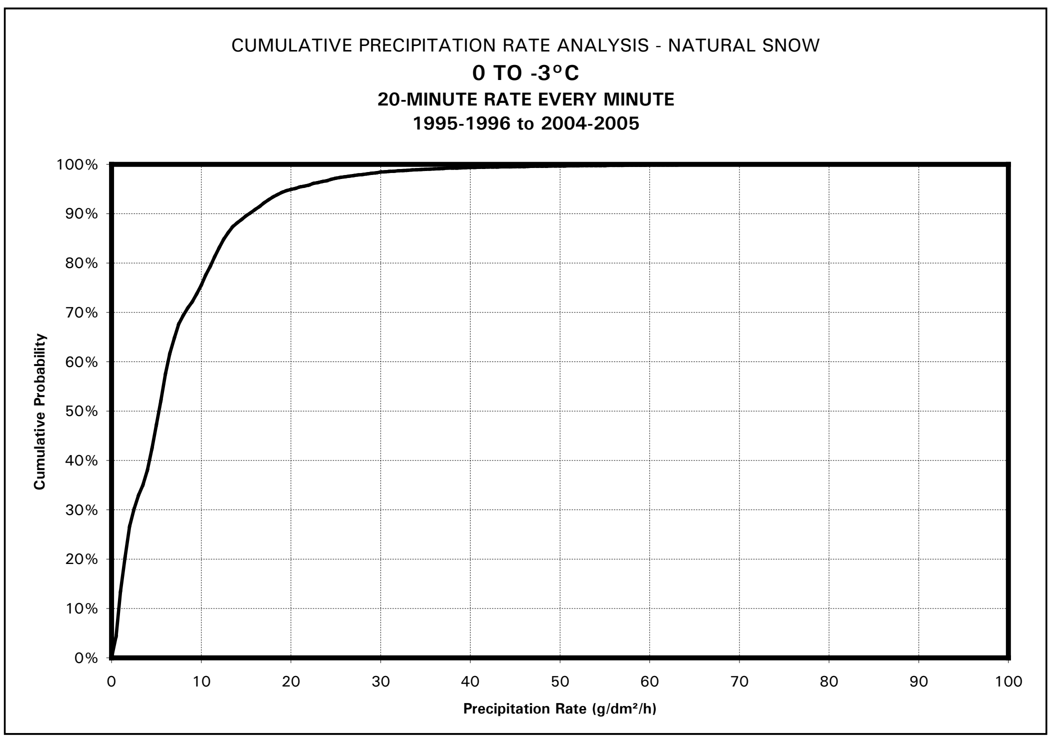
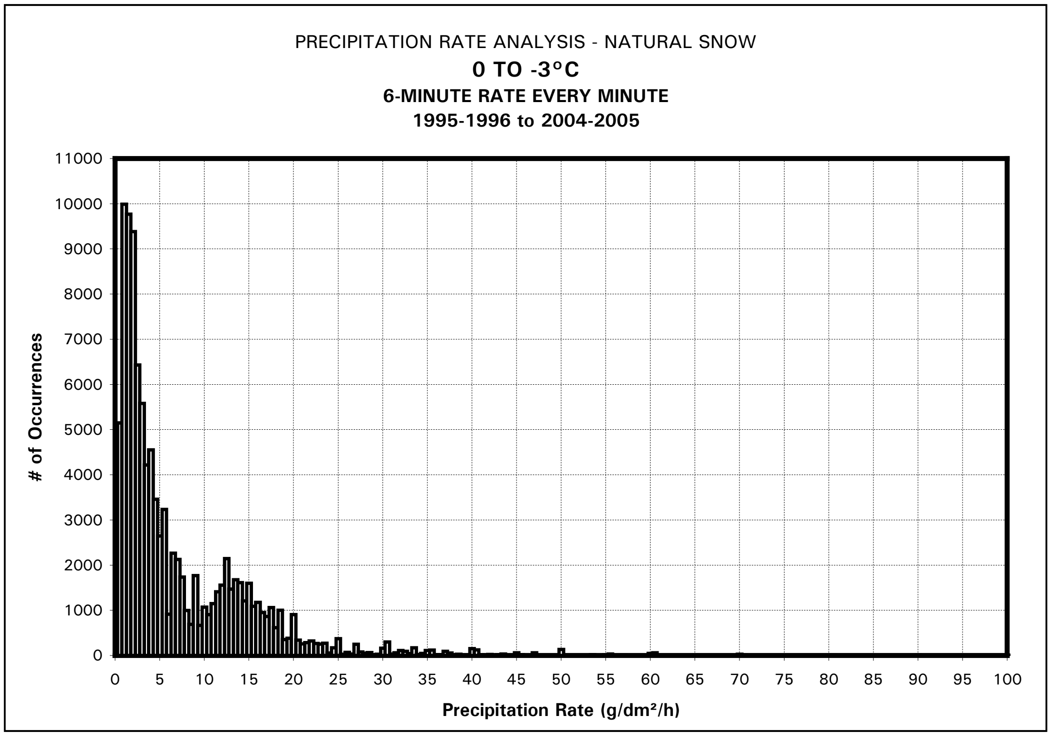
9000
10000
11000
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)


CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
0 TO -3°C
20-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
Cumulative Probability
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
0 10 20 30 40 50 60 70 80 90 100
Precipitation Rate (g/dm²/h)


PRECIPITATION RATE ANALYSIS - NATURAL SNOW
0 TO -3°C
6-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
# of Occurrences
0
1000
2000
3000
4000
5000
6000
7000
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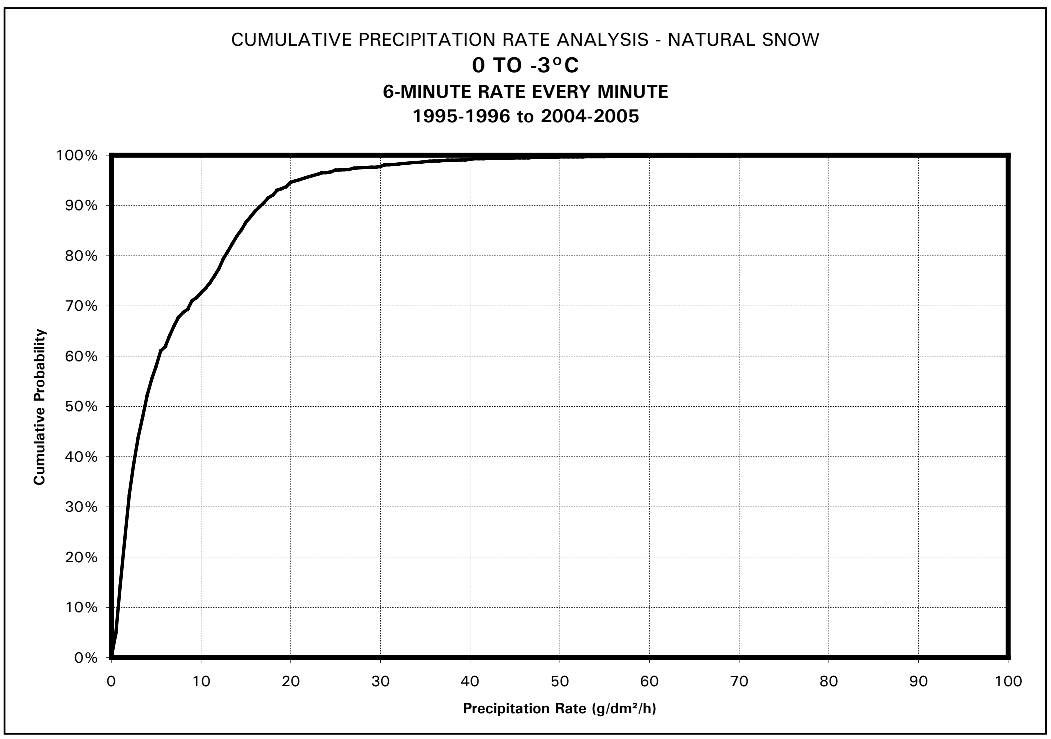
9000
10000
11000
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)


CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
0 TO -3°C
6-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
Cumulative Probability
0%
10%
20%
30%
40%
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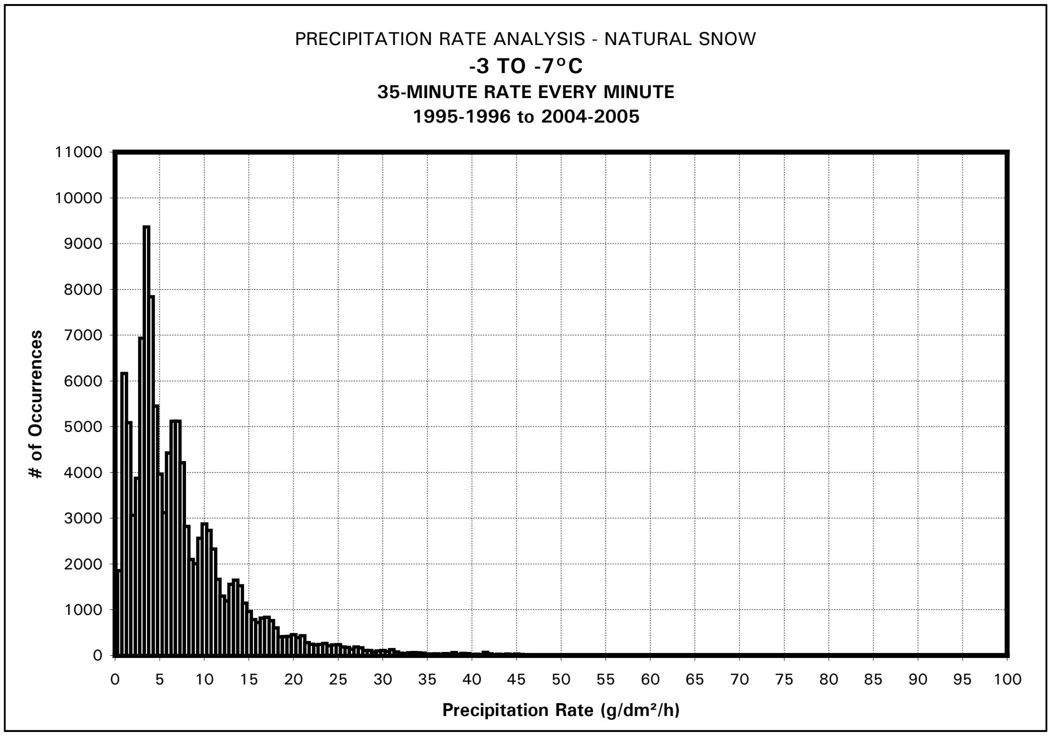
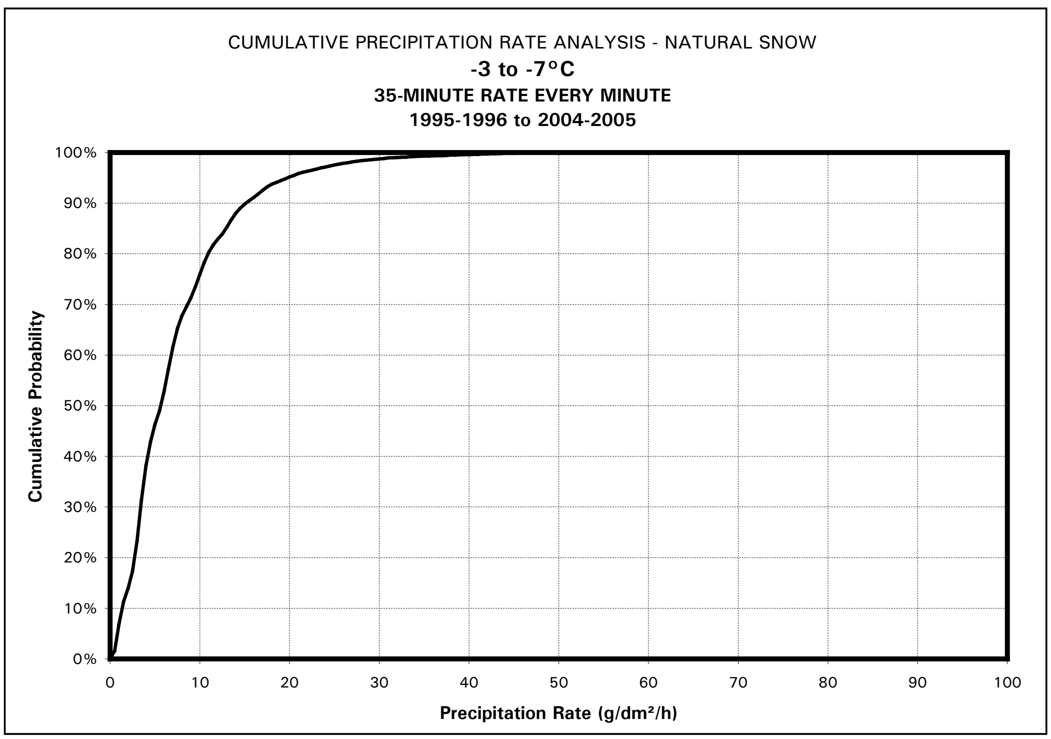
60%
70%
80%
90%
100%
0 10 20 30 40 50 60 70 80 90 100
Precipitation Rate (g/dm²/h)


PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-3 TO -7°C
35-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
# of Occurrences
Precipitation Rate (g/dm²/h)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100


CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-3 to -7°C
35-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
Cumulative Probability
Precipitation Rate (g/dm²/h)
0%
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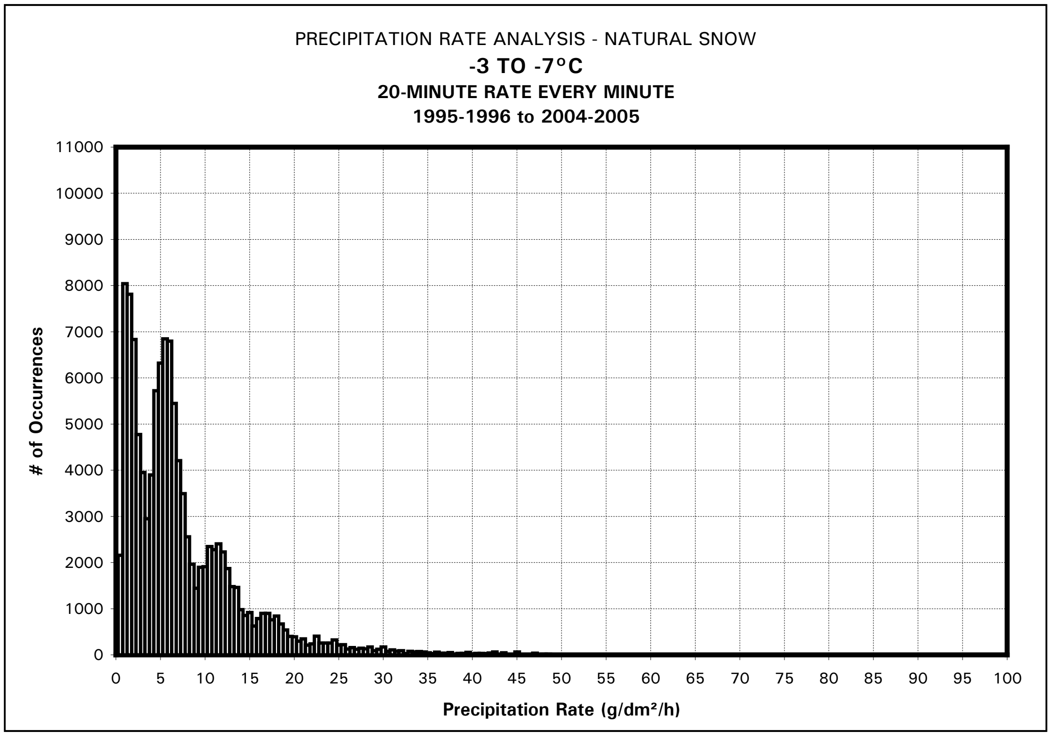
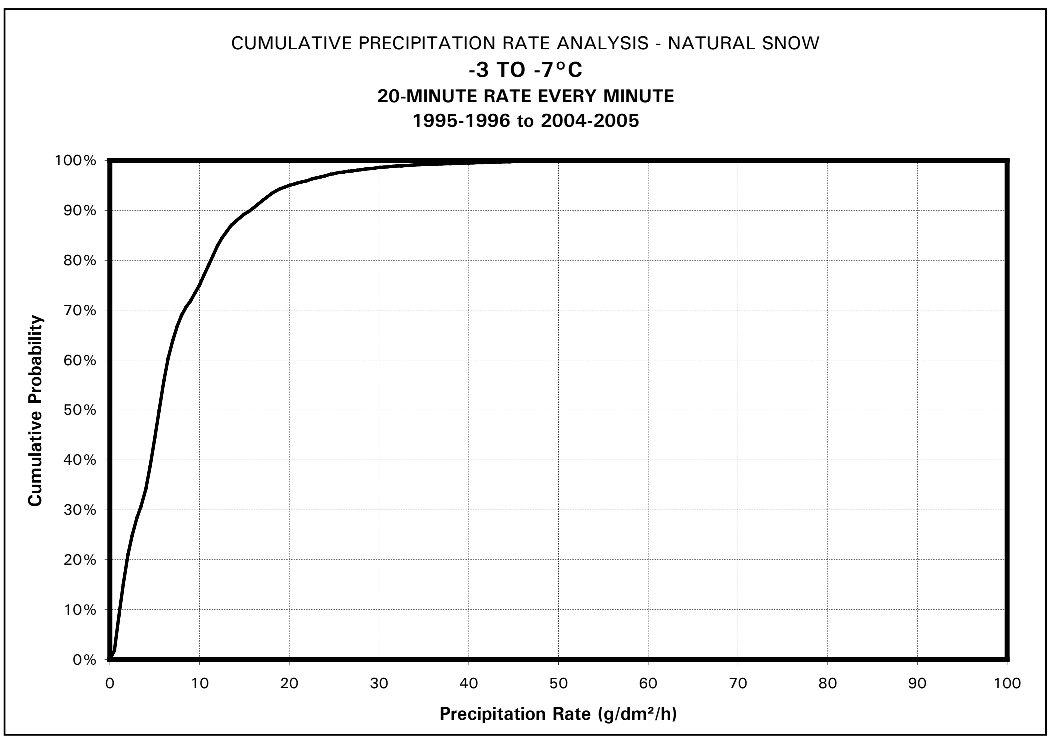
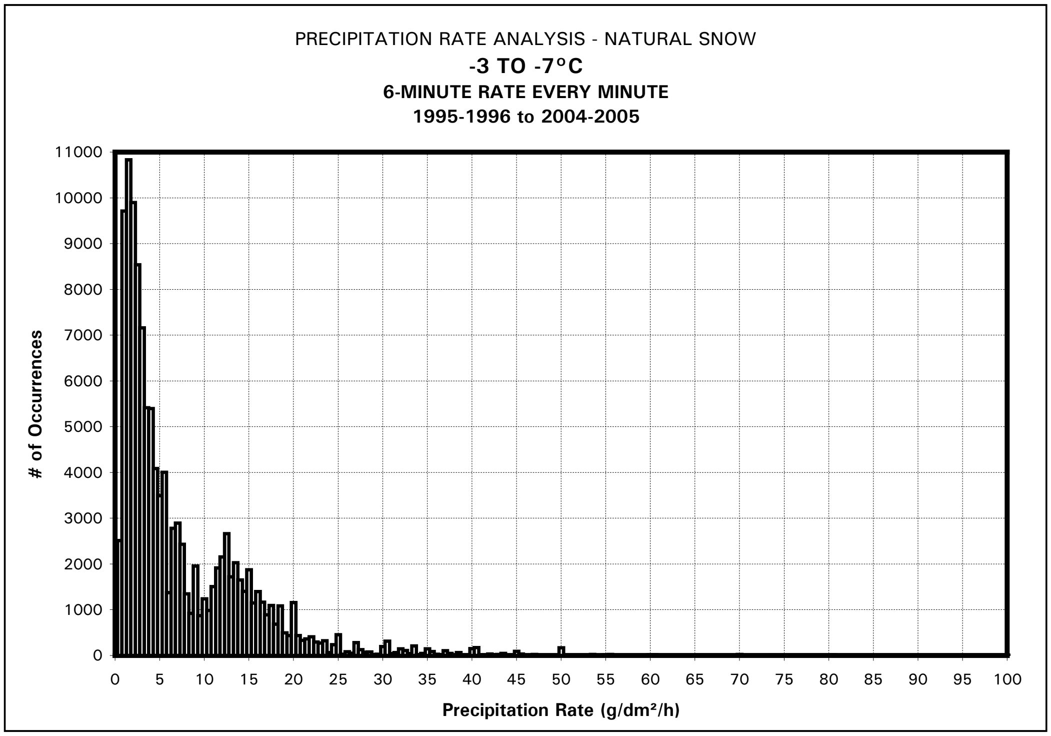
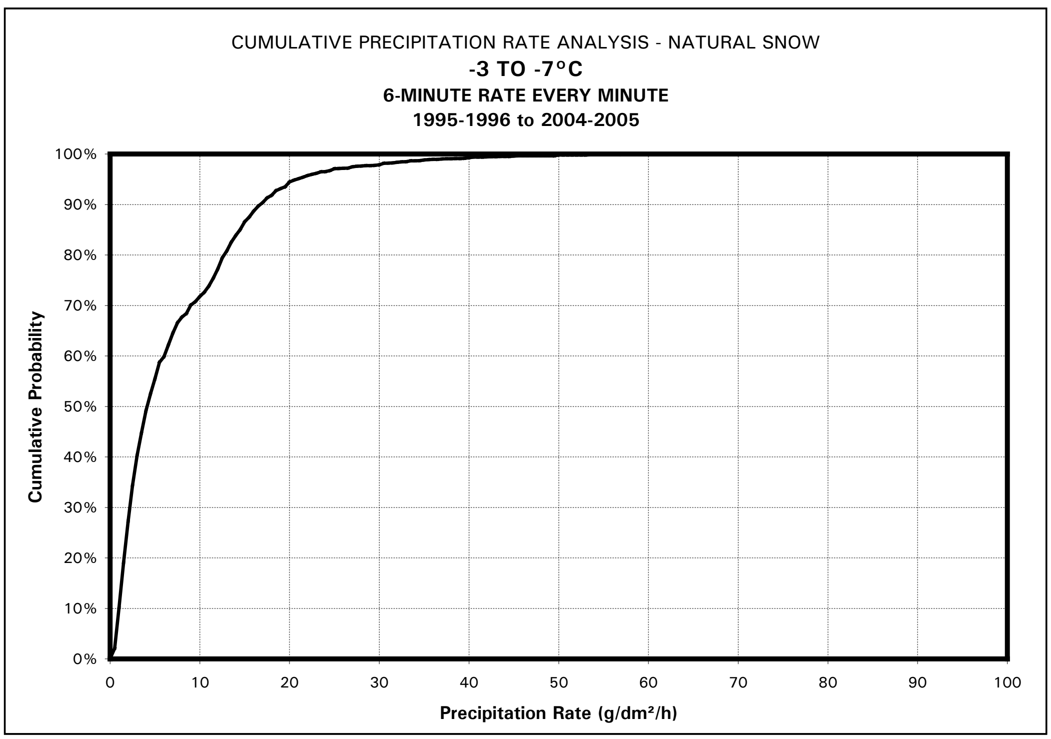
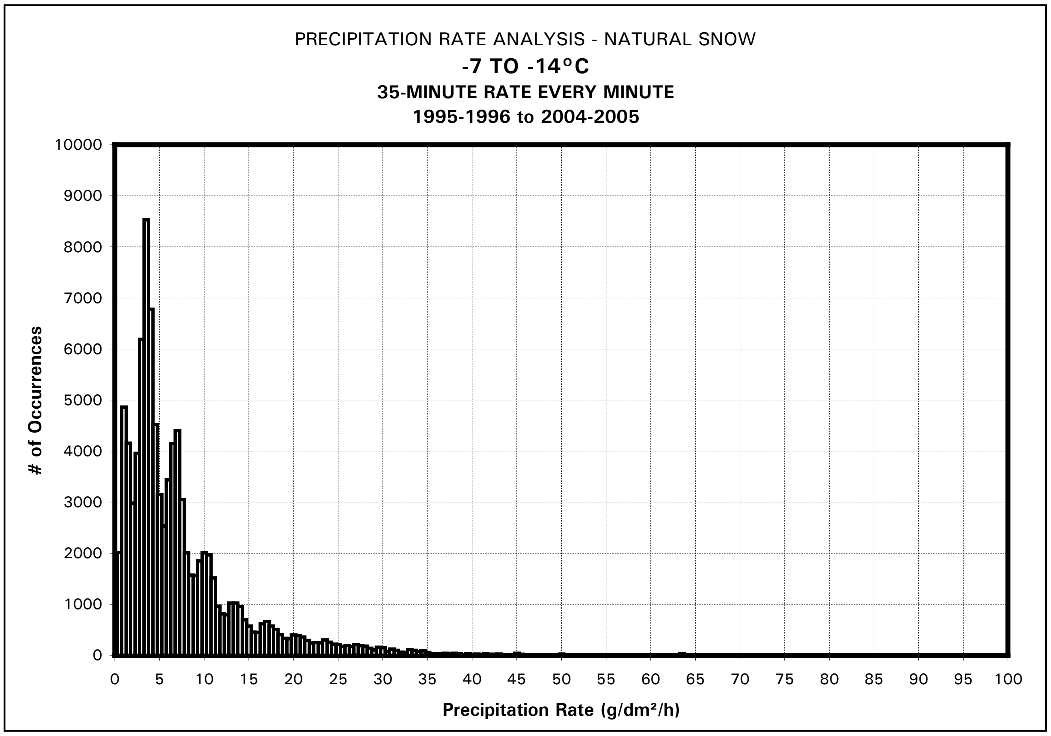
80%
90%
100%
0 10 20 30 40 50 60 70 80 90 100


PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-3 TO -7°C
20-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
# of Occurrences
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)


CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-3 TO -7°C
20-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
Cumulative Probability
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
0 10 20 30 40 50 60 70 80 90 100
Precipitation Rate (g/dm²/h)


PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-3 TO -7°C
6-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
# of Occurrences
Precipitation Rate (g/dm²/h)


CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-3 TO -7°C
6-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
Cumulative Probability
Precipitation Rate (g/dm²/h)


PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-7 TO -14°C
35-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
# of Occurrences
0
1000
2000
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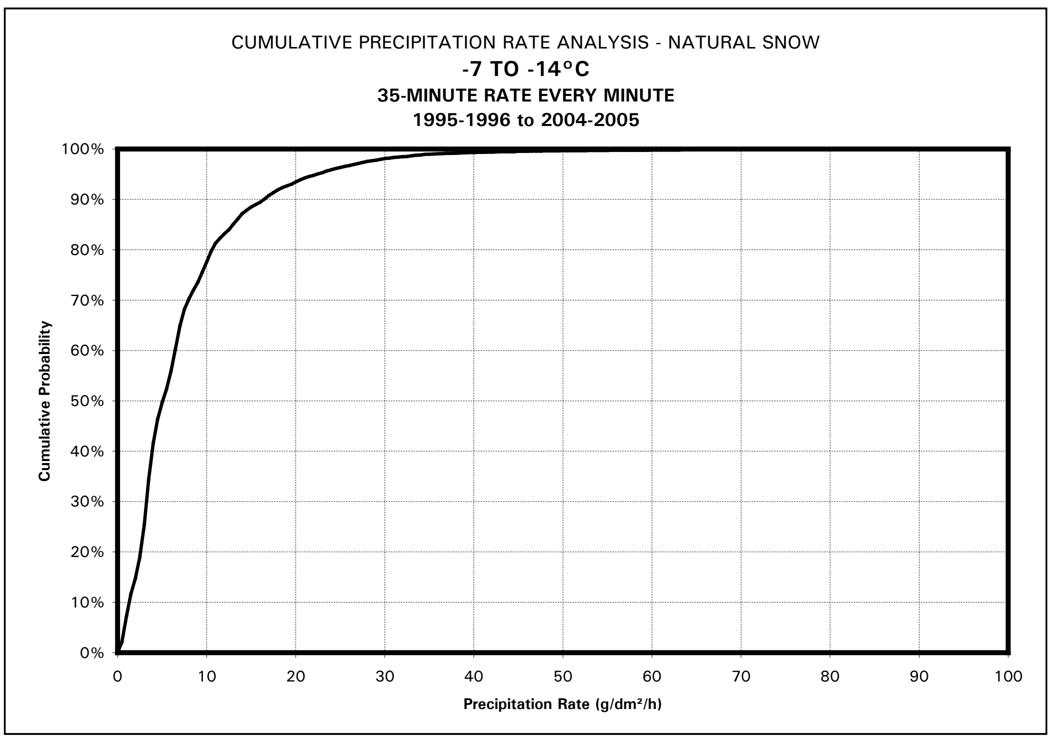
8000
9000
10000
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)


CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-7 TO -14°C
35-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
Cumulative Probability
0%
10%
20%
30%
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60%
70%
80%
90%
100%
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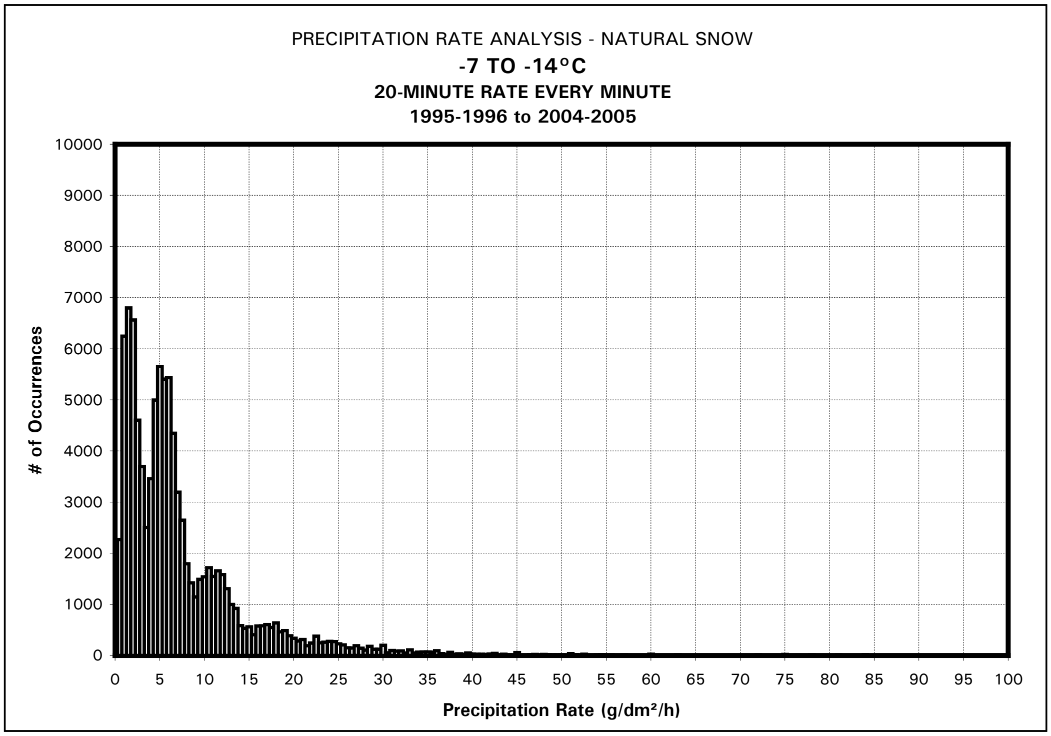
Precipitation Rate (g/dm²/h)


PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-7 TO -14°C
20-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
# of Occurrences
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2000
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6000
7000
8000
9000
10000
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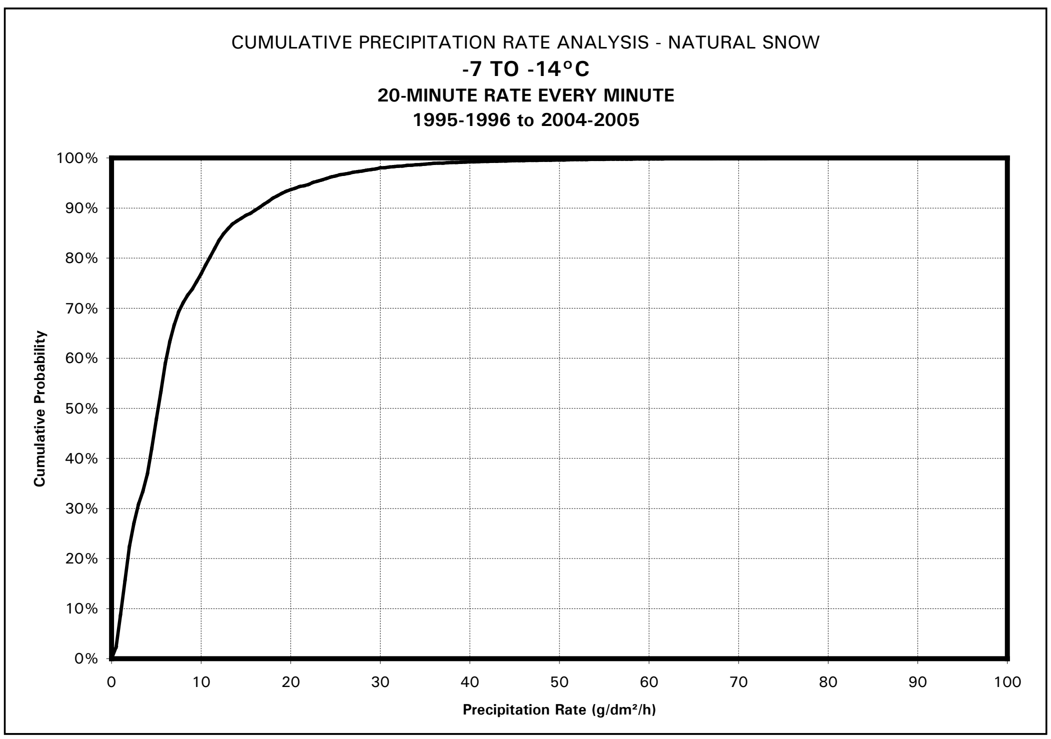
90
95
100
Precipitation Rate (g/dm²/h)


CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-7 TO -14°C
20-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
Cumulative Probability
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
0
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60
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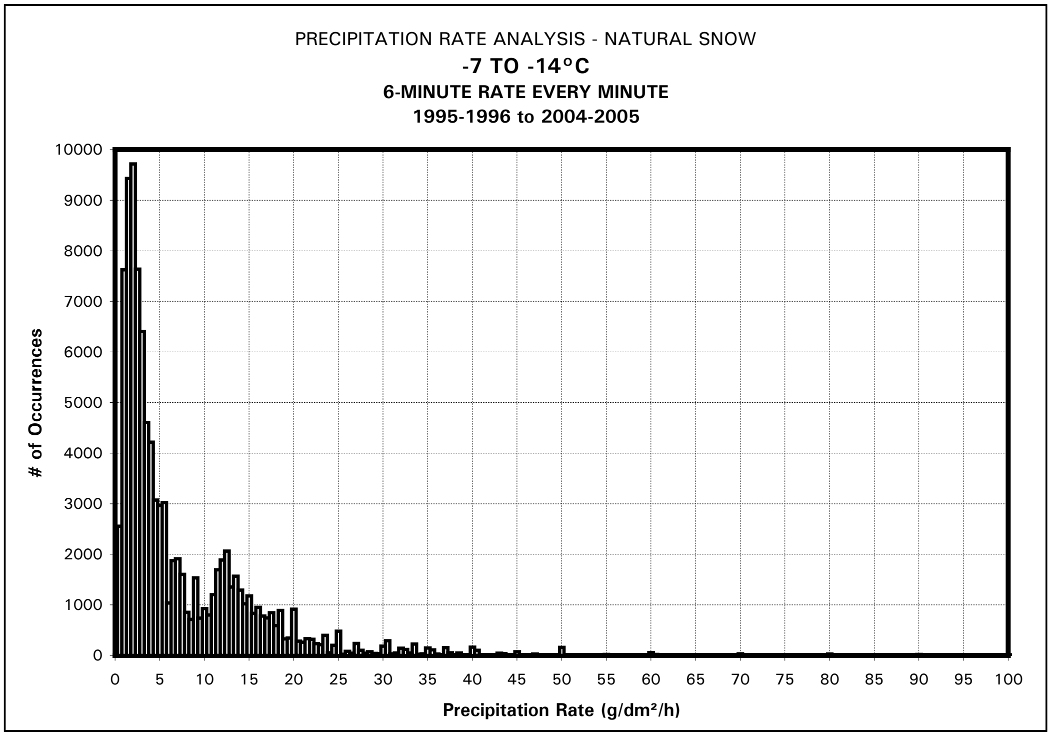
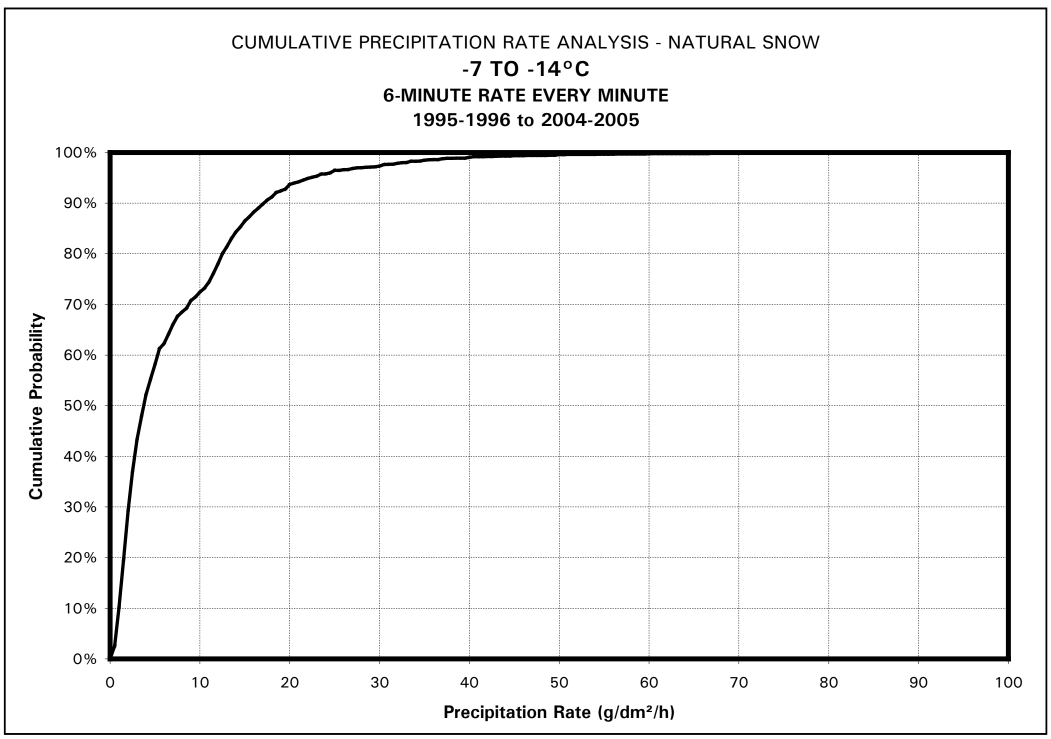
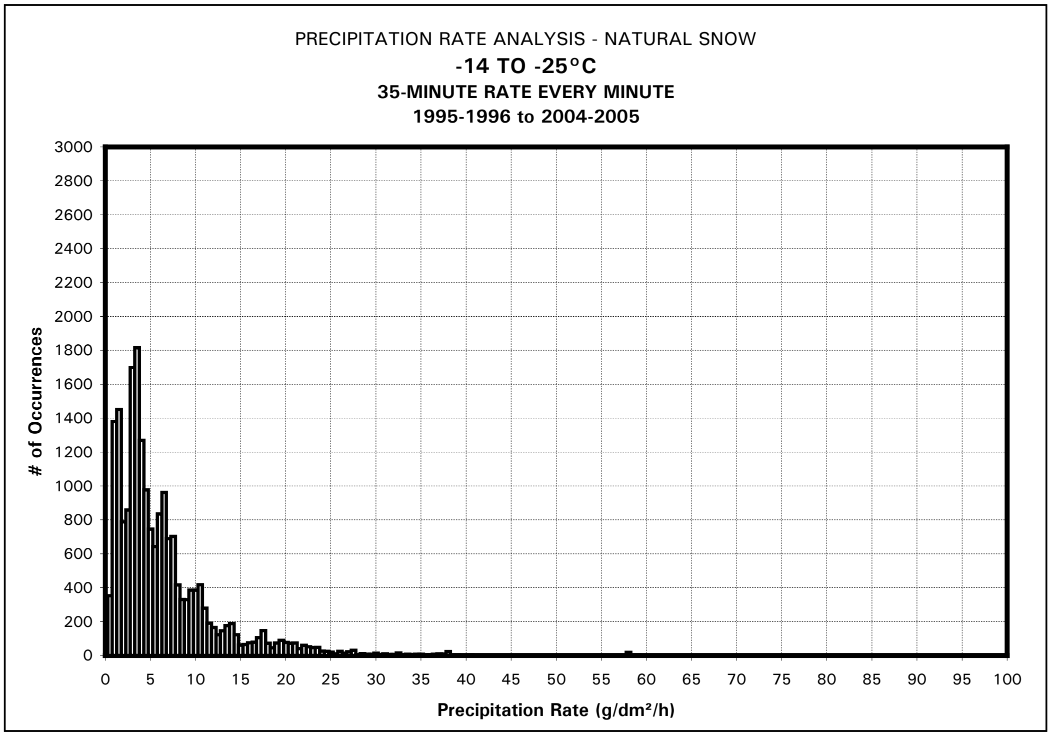
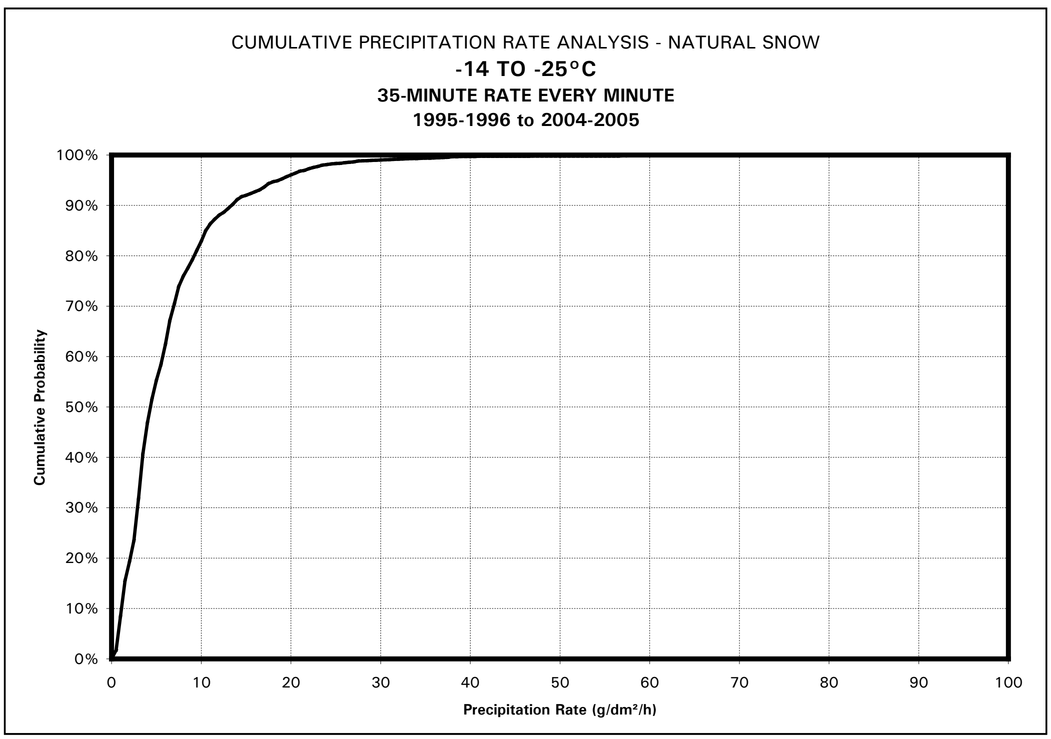
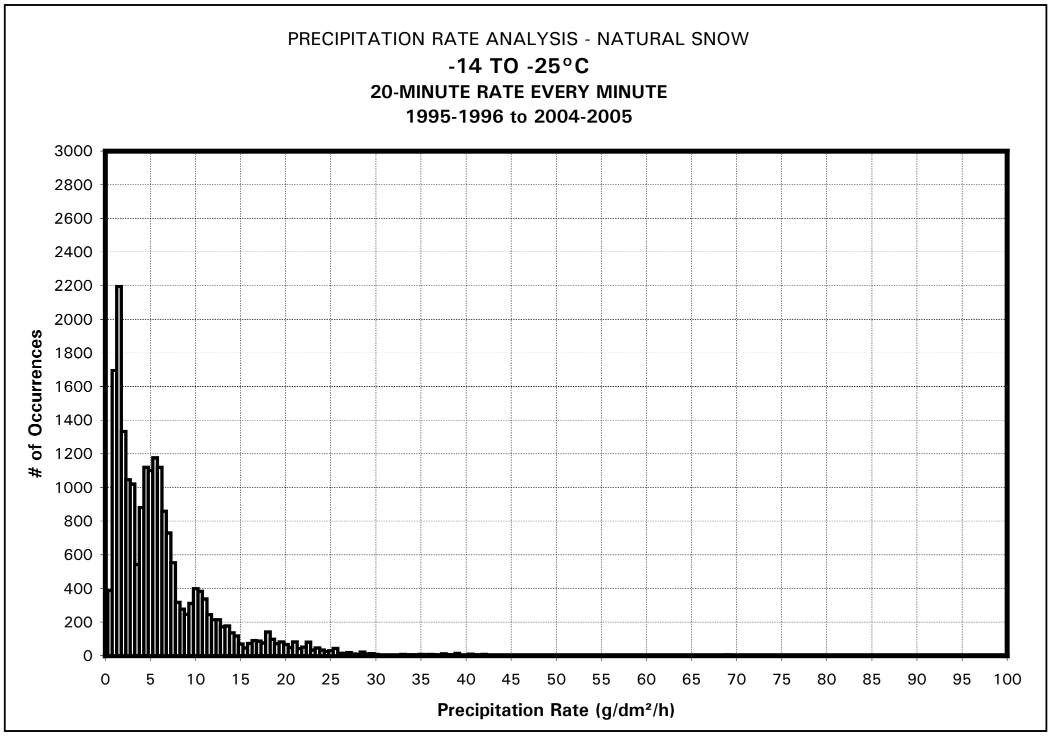
80
90
100
Precipitation Rate (g/dm²/h)


PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-7 TO -14°C
6-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
# of Occurrences
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)


CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-7 TO -14°C
6-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
Cumulative Probability
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
0 10 20 30 40 50 60 70 80 90 100
Precipitation Rate (g/dm²/h)


PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-14 TO -25°C
35-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
# of Occurrences
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)


CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-14 TO -25°C
35-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
Cumulative Probability
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0 10 20 30 40 50 60 70 80 90 100
Precipitation Rate (g/dm²/h)


PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-14 TO -25°C
20-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
# of Occurrences
Precipitation Rate (g/dm²/h)
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0
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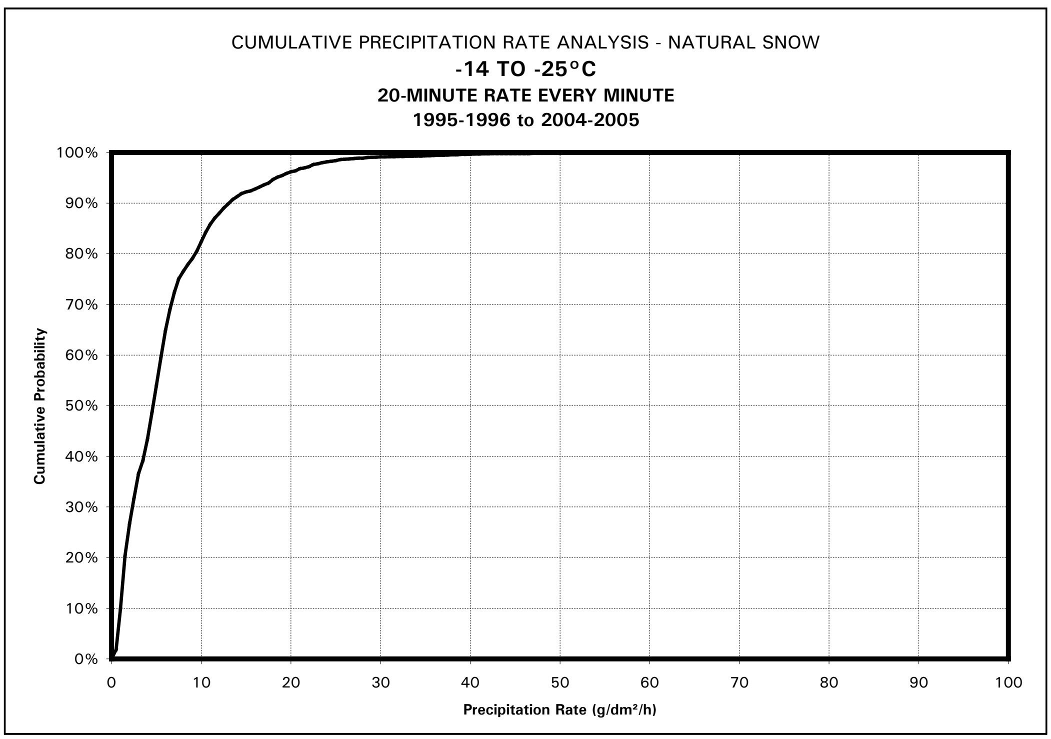
95
100


CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-14 TO -25°C
20-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
Cumulative Probability
Precipitation Rate (g/dm²/h)
100%
90%
80%
70%
60%
50%
40%
30%
20%
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0%
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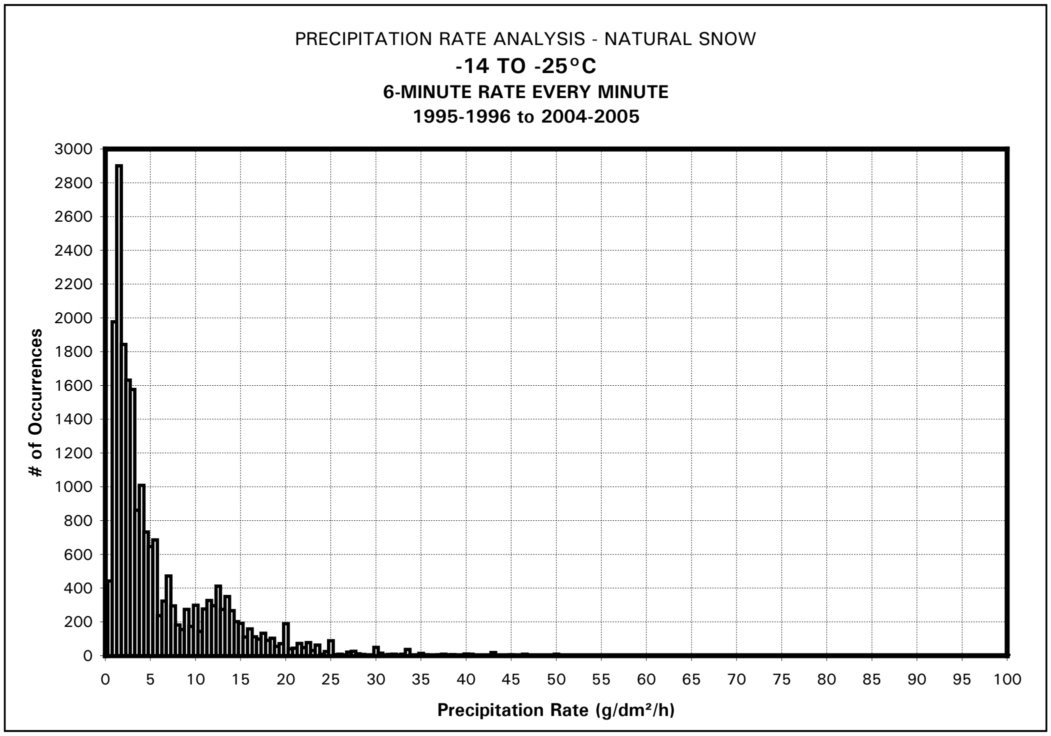
PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-14 TO -25°C
6-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
# of Occurrences
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
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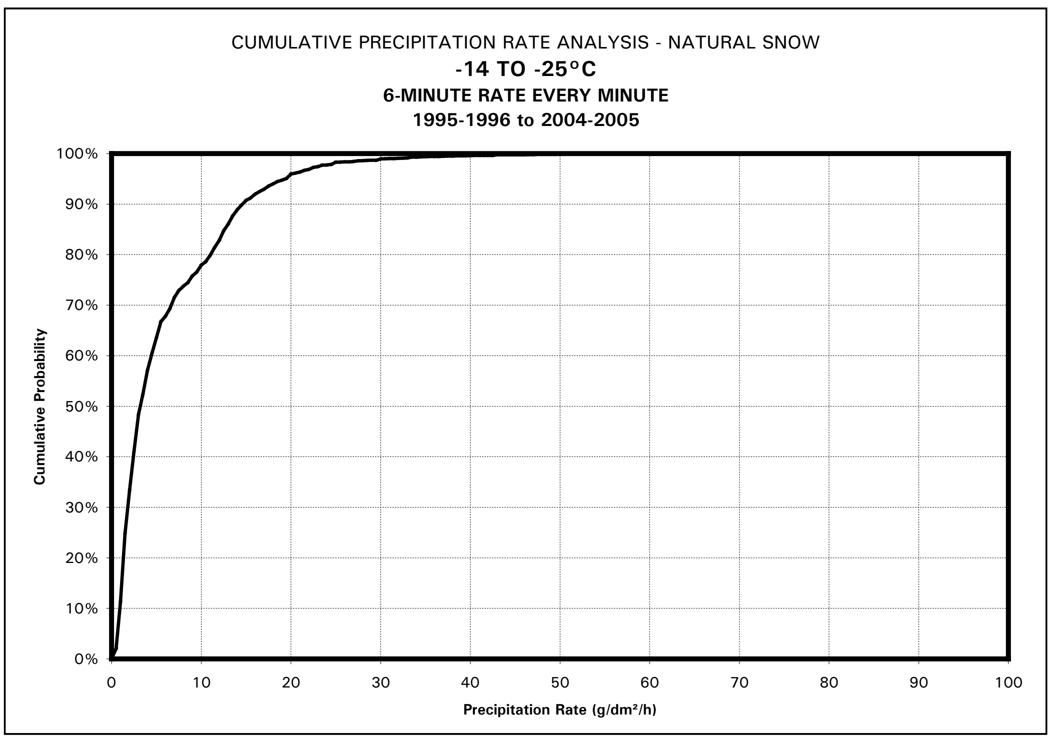
600
400
200
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)


CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-14 TO -25°C
6-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
Cumulative Probability
100%
90%
80%
70%
60%
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0%
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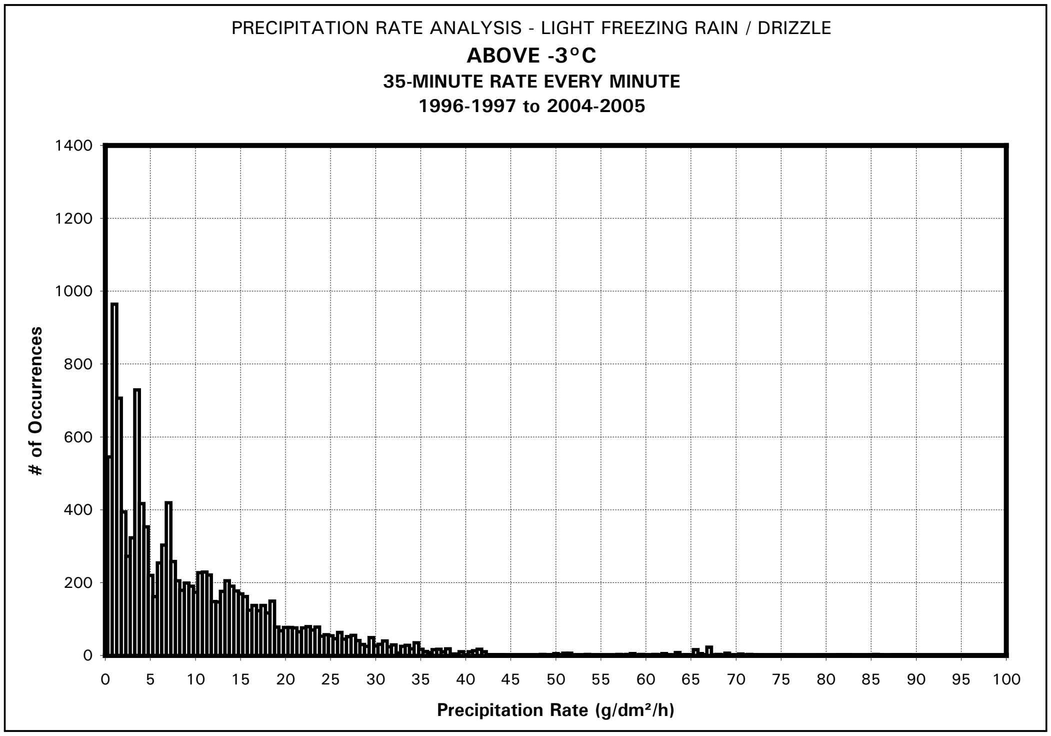
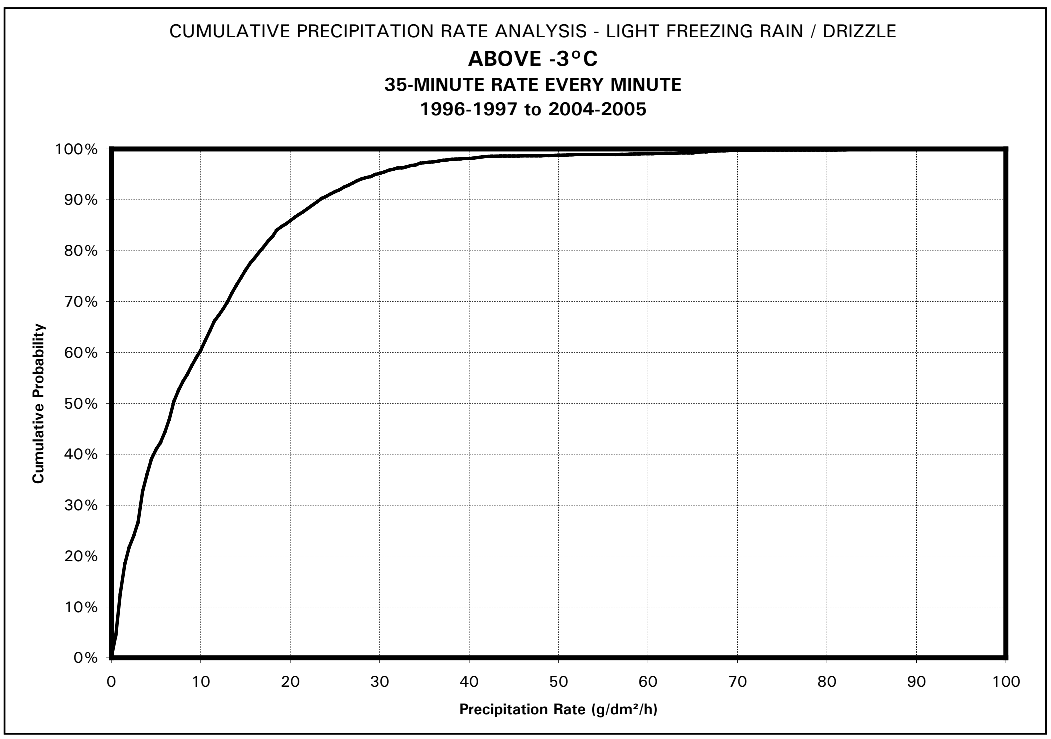
Precipitation Rate (g/dm²/h)


PRECIPITATION RATE ANALYSIS - LIGHT FREEZING RAIN / DRIZZLE
ABOVE -3°C
35-MINUTE RATE EVERY MINUTE
1996-1997 to 2004-2005
# of Occurrences
0
200
400
600
800
1000
1200
1400
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)


CUMULATIVE PRECIPITATION RATE ANALYSIS - LIGHT FREEZING RAIN / DRIZZLE
ABOVE -3°C
35-MINUTE RATE EVERY MINUTE
1996-1997 to 2004-2005
Cumulative Probability
0%
10%
20%
30%
40%
50%
60%
70%
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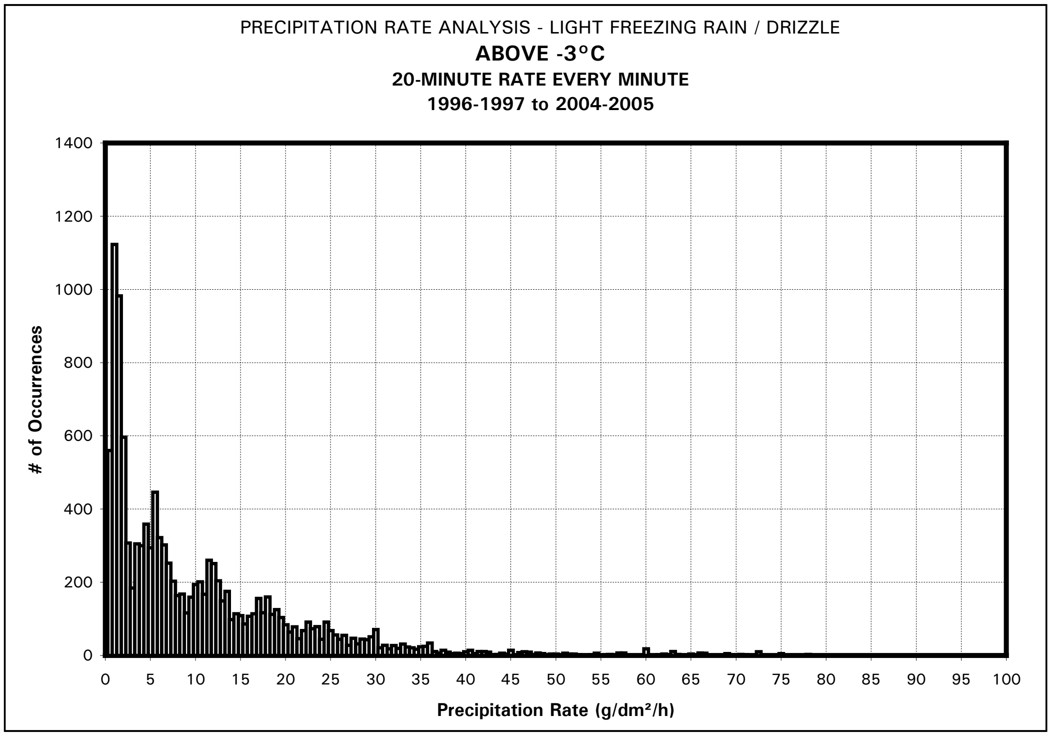
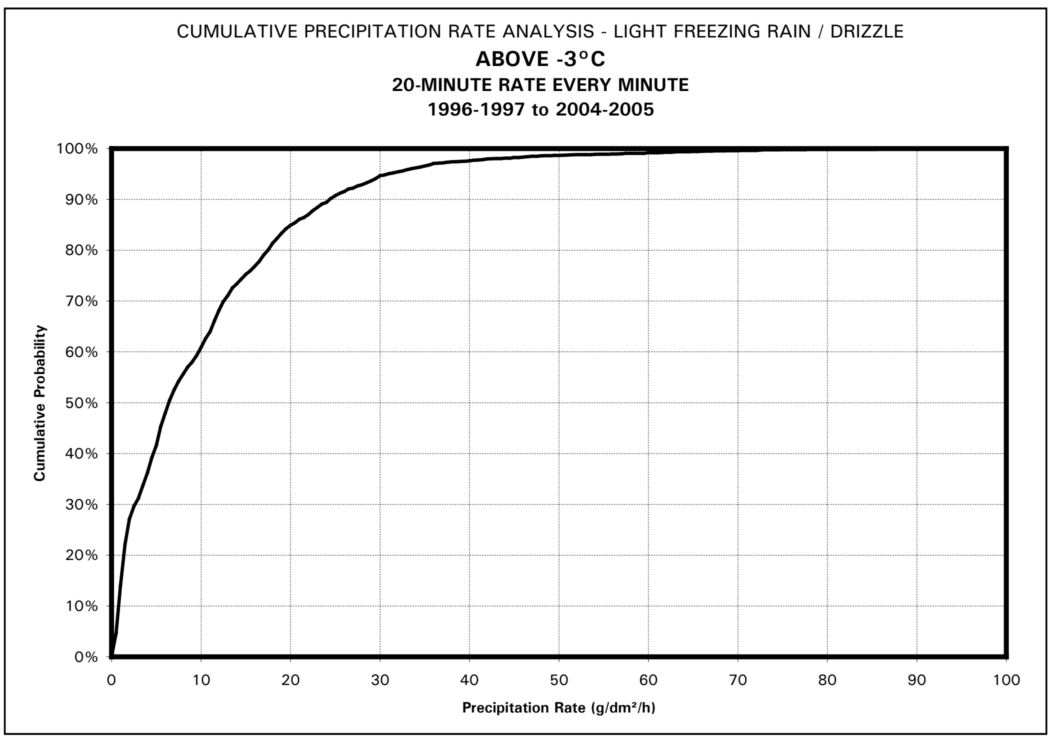
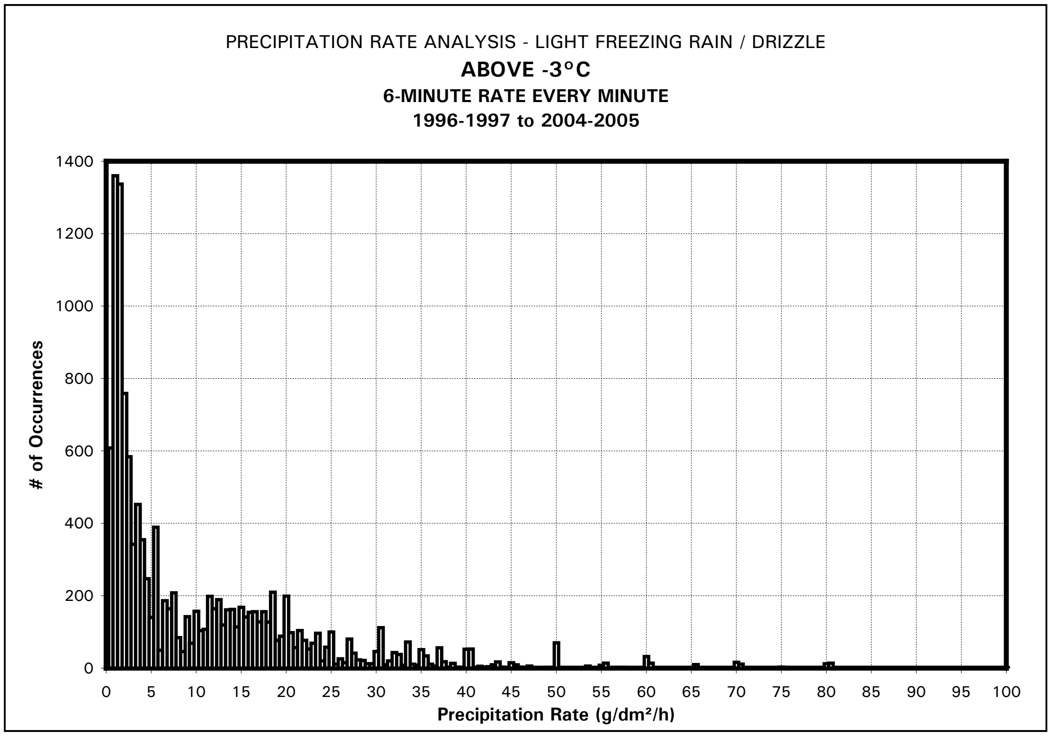
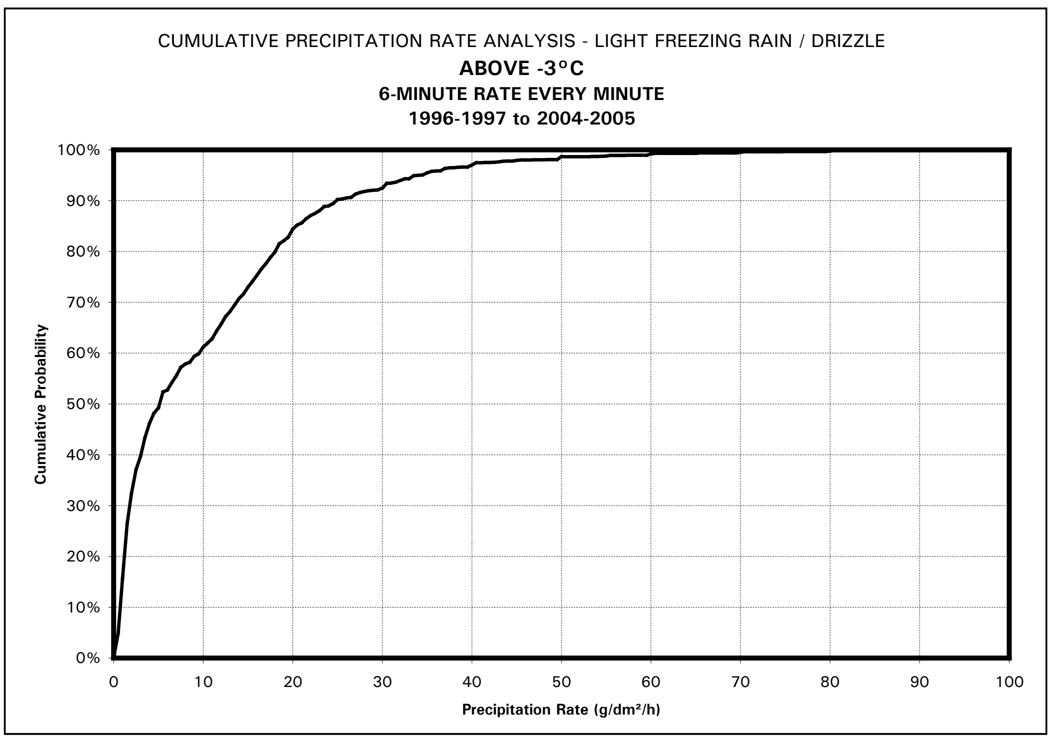
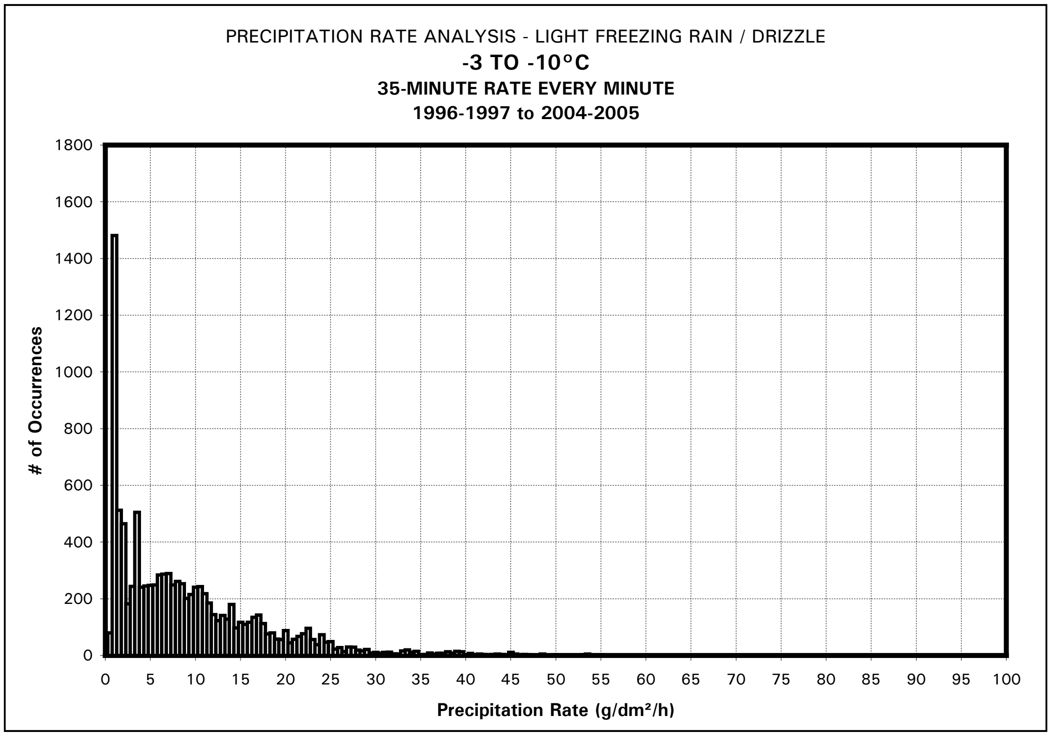
90%
100%
0 10 20 30 40 50 60 70 80 90 100
Precipitation Rate (g/dm²/h)

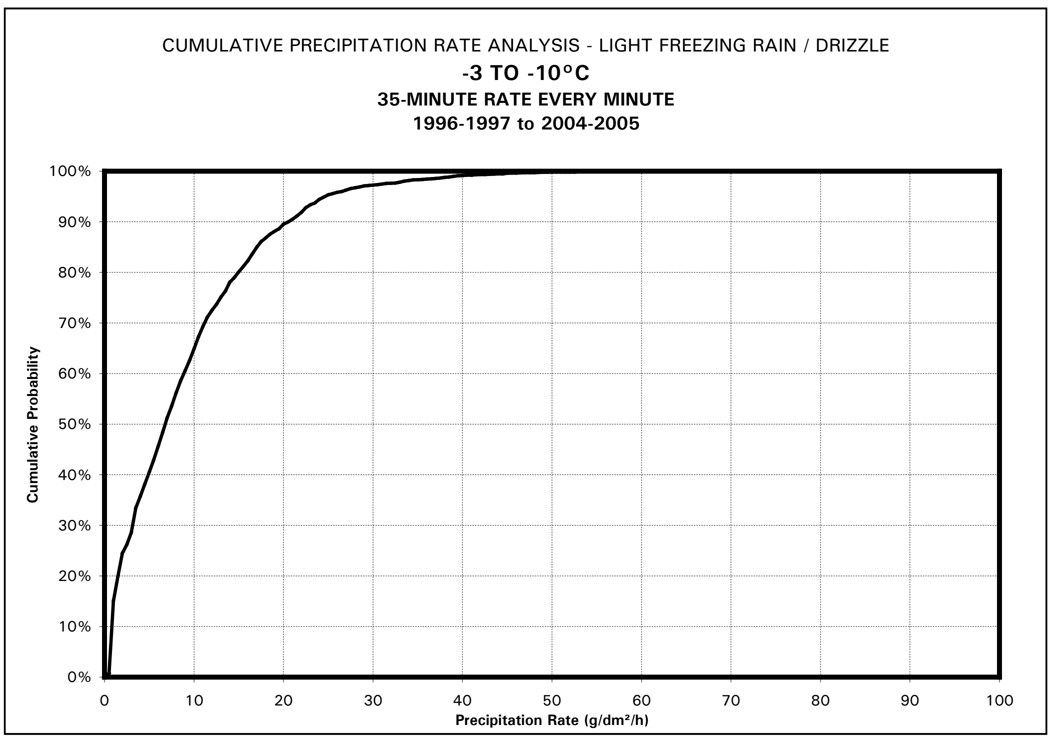

PRECIPITATION RATE ANALYSIS - LIGHT FREEZING RAIN / DRIZZLE
ABOVE -3°C
20-MINUTE RATE EVERY MINUTE
1996-1997 to 2004-2005
# of Occurrences
0
200
400
600
800
1000
1200
1400
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)

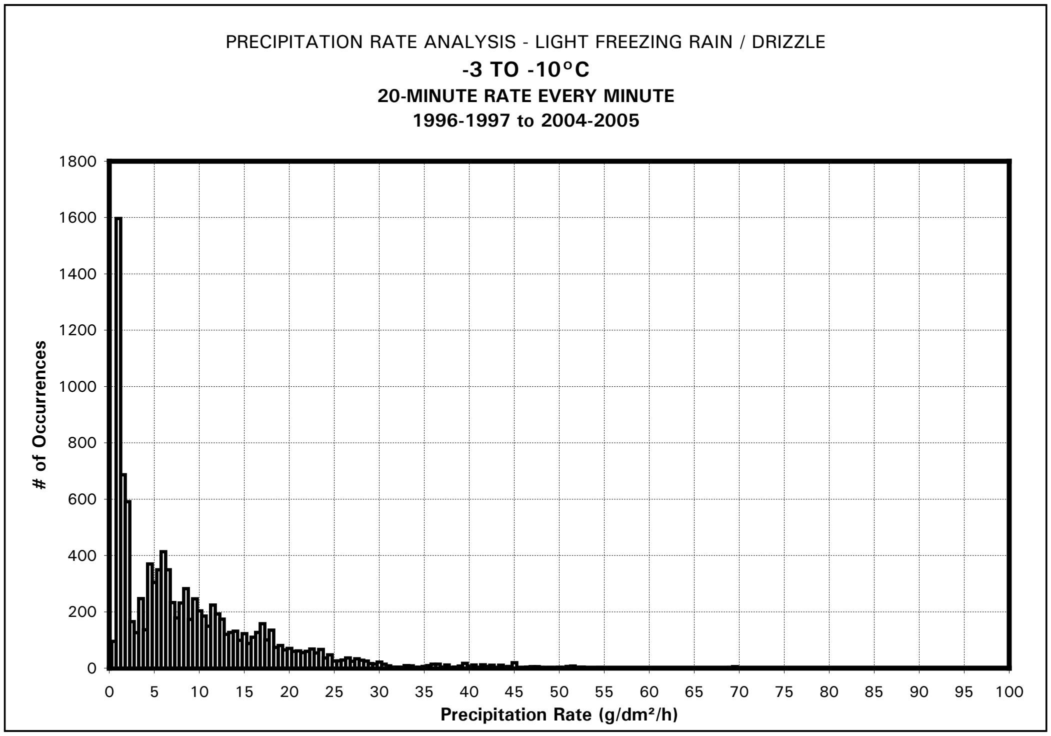

CUMULATIVE PRECIPITATION RATE ANALYSIS - LIGHT FREEZING RAIN / DRIZZLE
ABOVE -3°C
20-MINUTE RATE EVERY MINUTE
1996-1997 to 2004-2005
Cumulative Probability
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
0 10 20 30 40 50 60 70 80 90 100
Precipitation Rate (g/dm²/h)


PRECIPITATION RATE ANALYSIS - LIGHT FREEZING RAIN / DRIZZLE
ABOVE -3°C
6-MINUTE RATE EVERY MINUTE
1996-1997 to 2004-2005
# of Occurrences
0
200
400
600
800
1000
1200
1400
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)


CUMULATIVE PRECIPITATION RATE ANALYSIS - LIGHT FREEZING RAIN / DRIZZLE
ABOVE -3°C
6-MINUTE RATE EVERY MINUTE
1996-1997 to 2004-2005
Cumulative Probability
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
0 10 20 30 40 50 60 70 80 90 100
Precipitation Rate (g/dm²/h)


PRECIPITATION RATE ANALYSIS - LIGHT FREEZING RAIN / DRIZZLE
-3 TO -10°C
35-MINUTE RATE EVERY MINUTE
1996-1997 to 2004-2005
# of Occurrences
0
200
400
600
800
1000
1200
1400
1600
1800
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)


CUMULATIVE PRECIPITATION RATE ANALYSIS - LIGHT FREEZING RAIN / DRIZZLE
-3 TO -10°C
35-MINUTE RATE EVERY MINUTE
1996-1997 to 2004-2005
Cumulative Probability
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
0 10 20 30 40 50 60 70 80 90 100
Precipitation Rate (g/dm²/h)


PRECIPITATION RATE ANALYSIS - LIGHT FREEZING RAIN / DRIZZLE
-3 TO -10°C
20-MINUTE RATE EVERY MINUTE
1996-1997 to 2004-2005
# of Occurrences
0
200
400
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800
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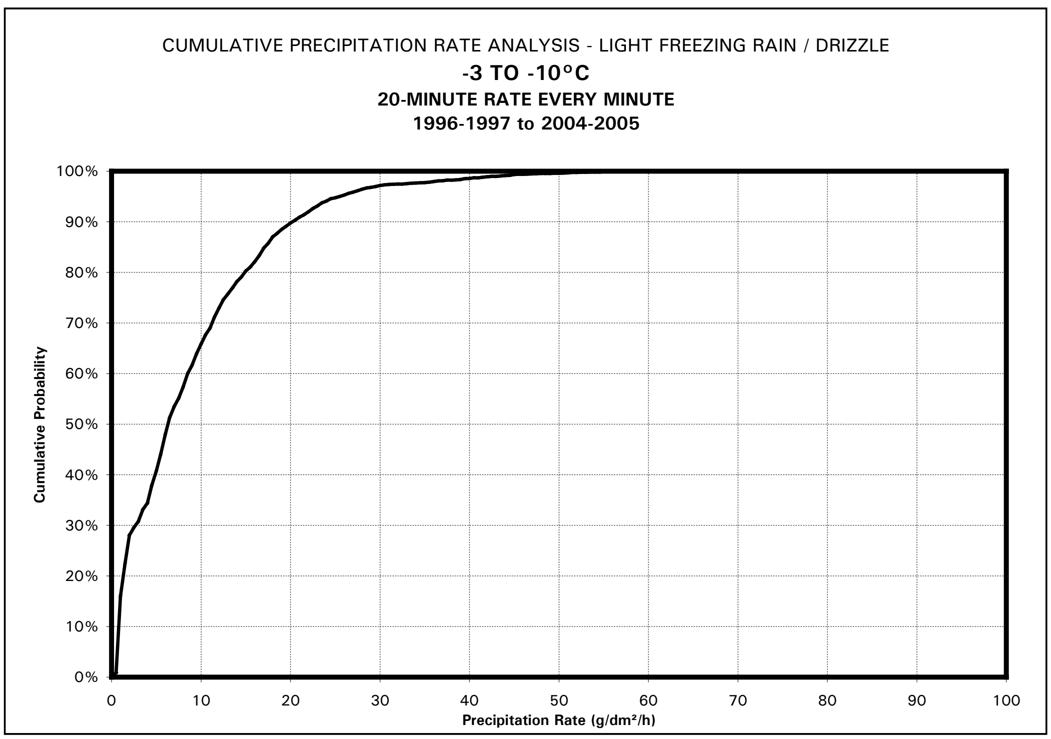
1400
1600
1800
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)


CUMULATIVE PRECIPITATION RATE ANALYSIS - LIGHT FREEZING RAIN / DRIZZLE
-3 TO -10°C
20-MINUTE RATE EVERY MINUTE
1996-1997 to 2004-2005
Cumulative Probability
0%
10%
20%
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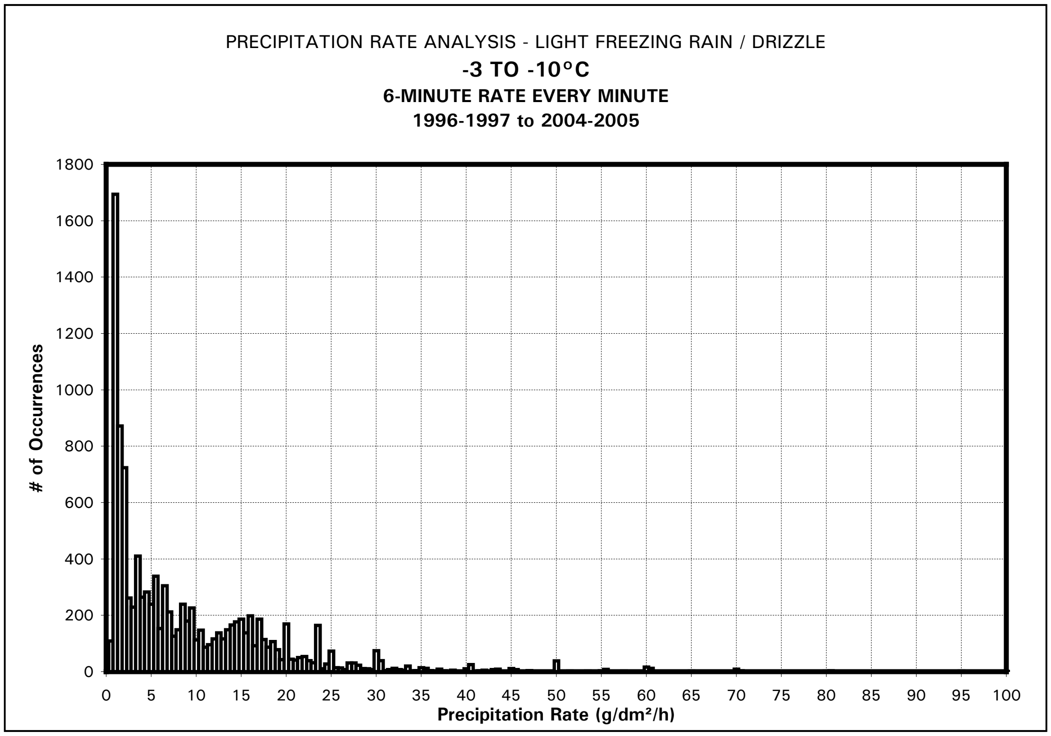
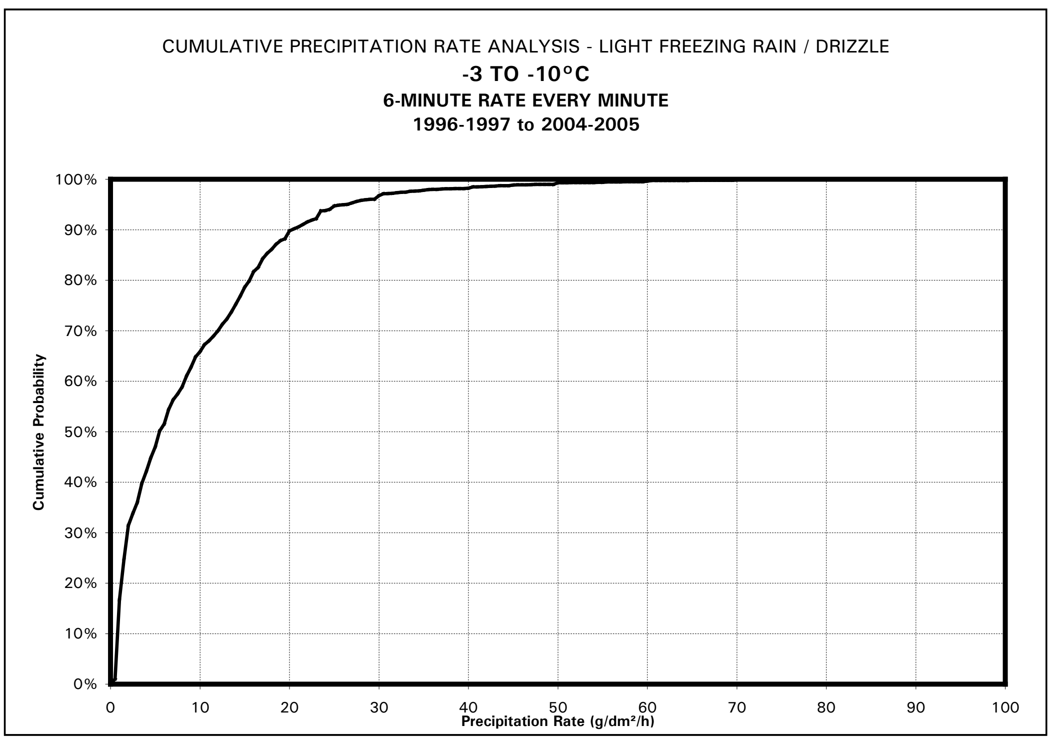
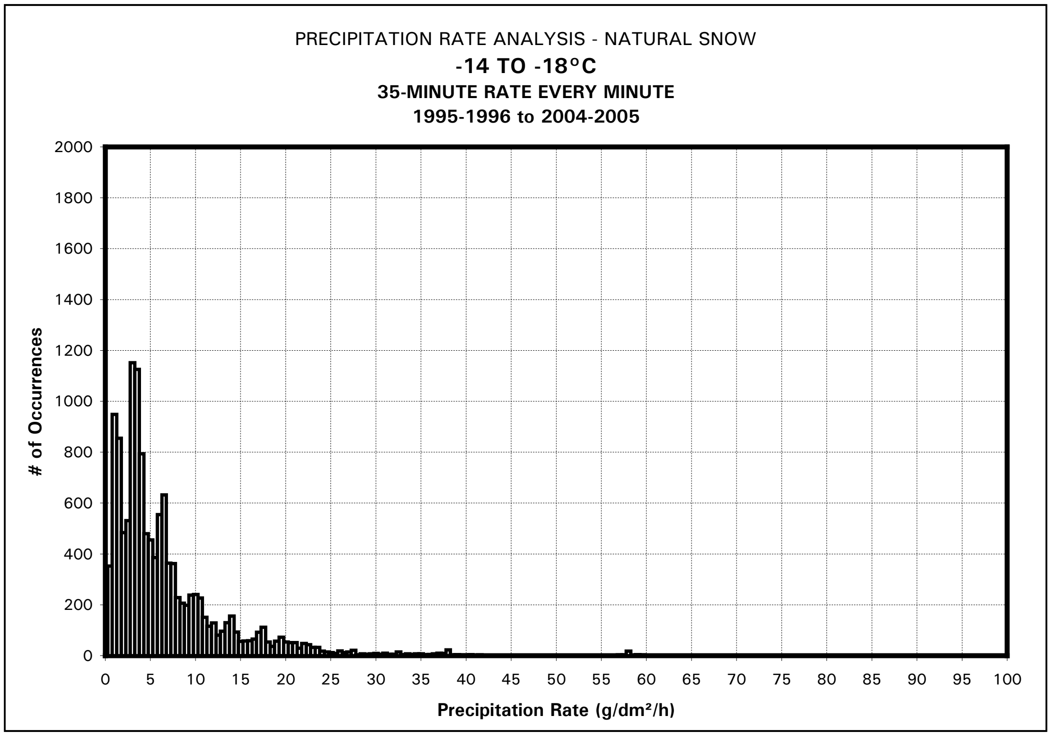
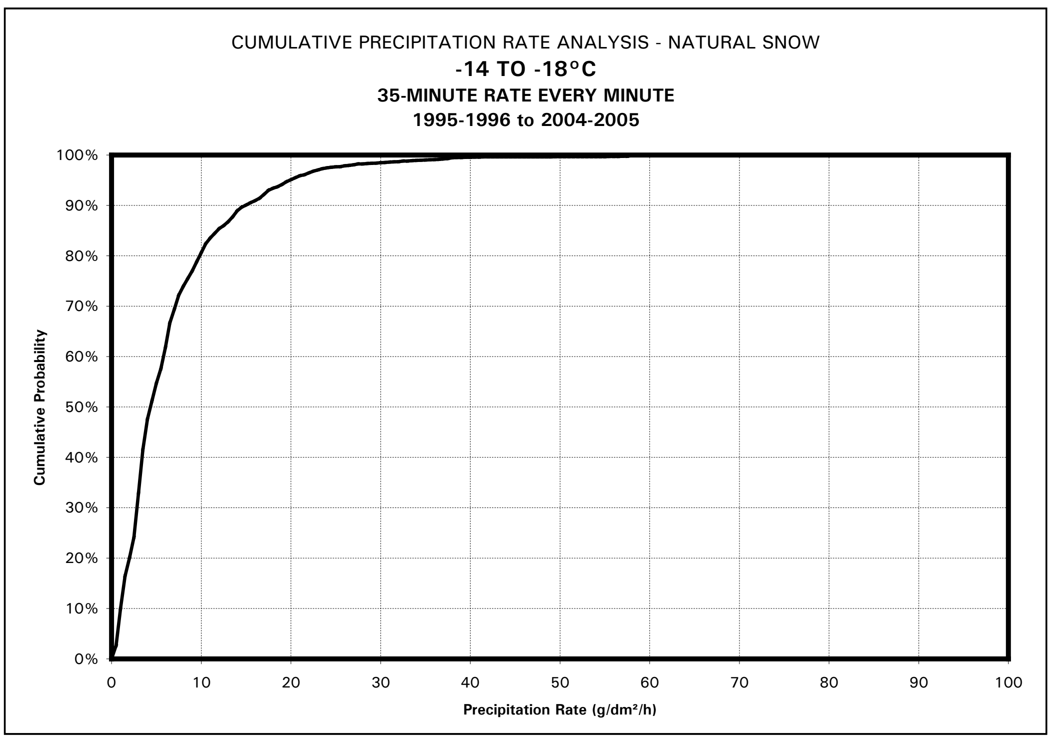
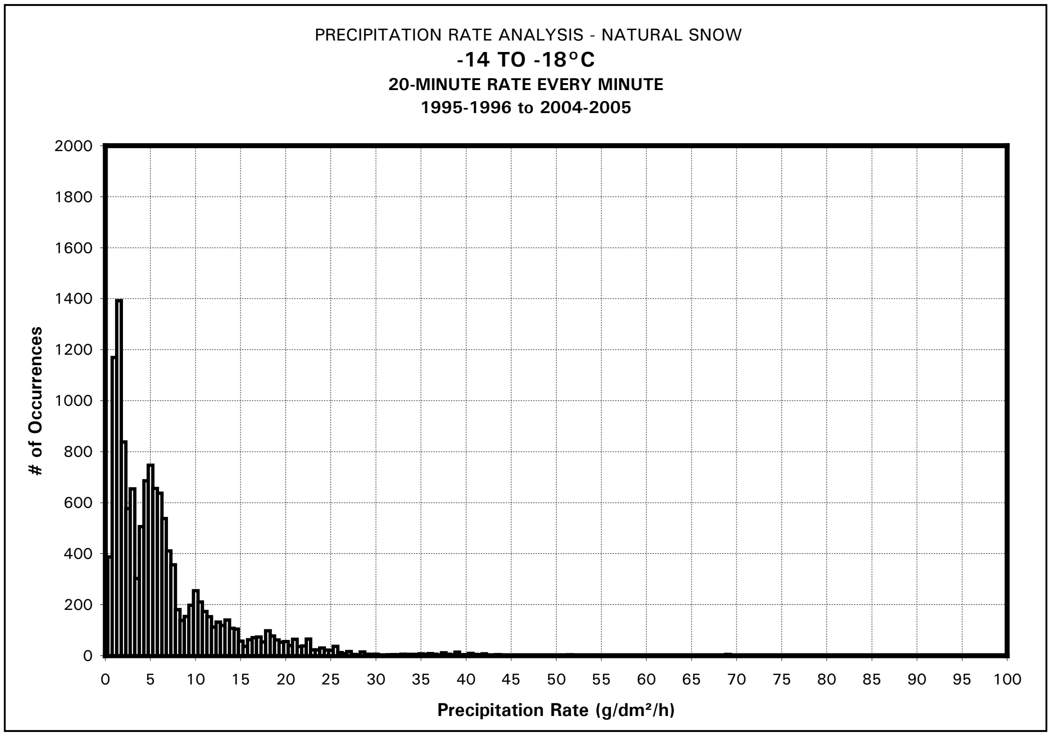
70%
80%
90%
100%
0 10 20 30 40 50 60 70 80 90 100
Precipitation Rate (g/dm²/h)

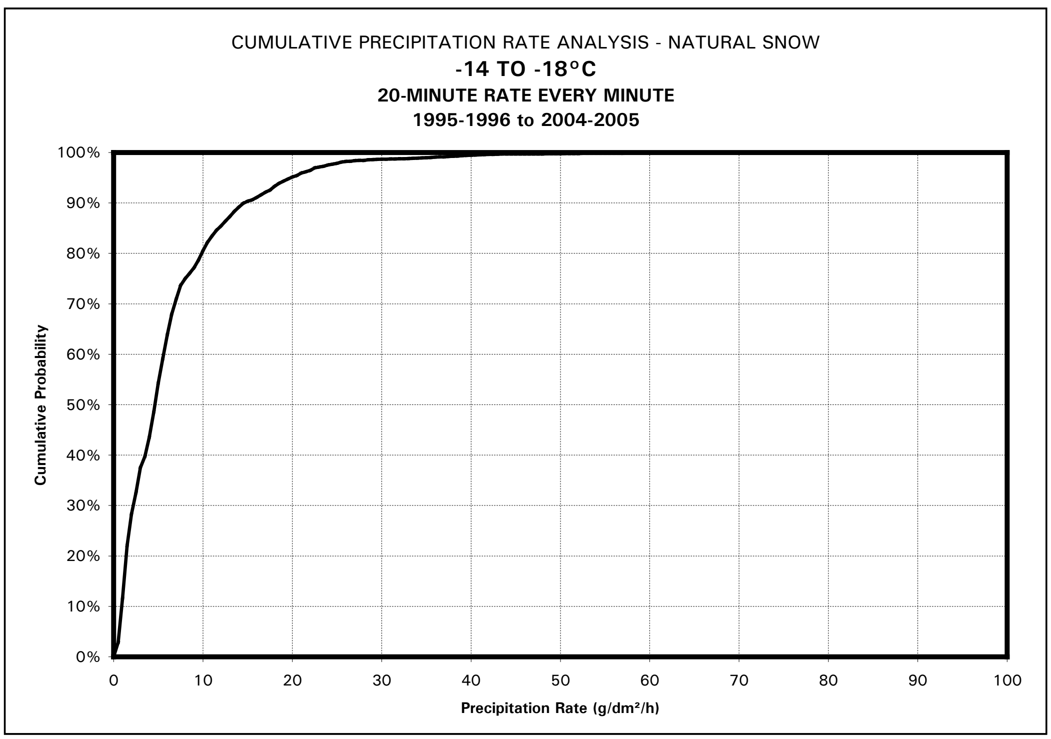

PRECIPITATION RATE ANALYSIS - LIGHT FREEZING RAIN / DRIZZLE
-3 TO -10°C
6-MINUTE RATE EVERY MINUTE
1996-1997 to 2004-2005
# of Occurrences
Precipitation Rate (g/dm²/h)

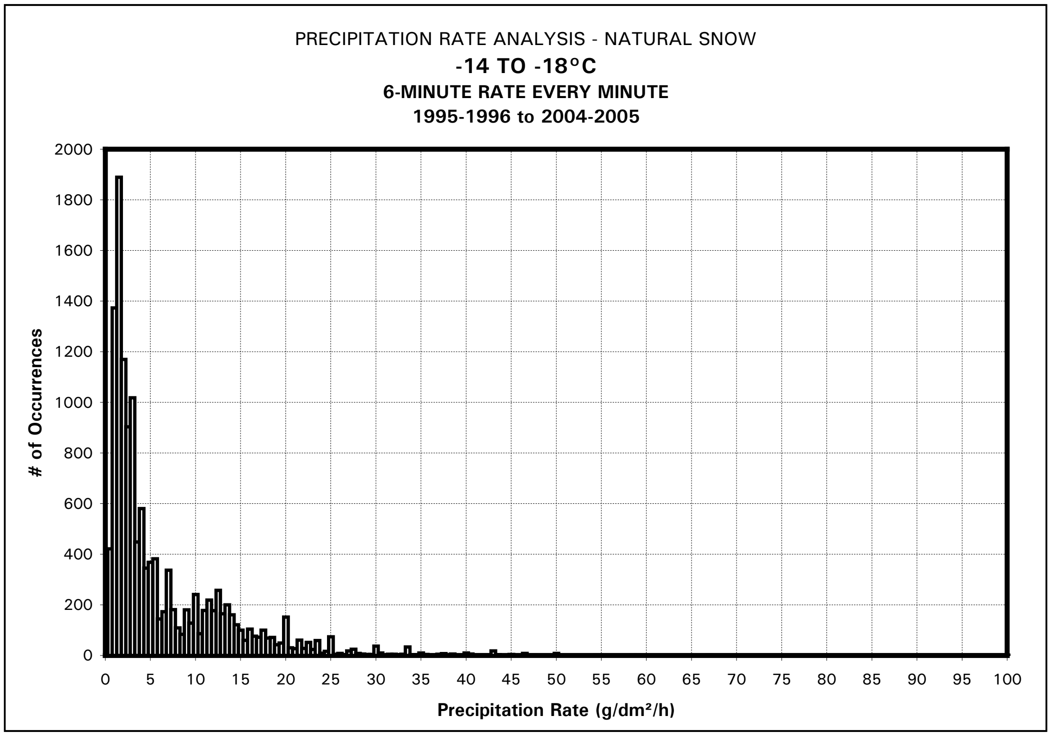

CUMULATIVE PRECIPITATION RATE ANALYSIS - LIGHT FREEZING RAIN / DRIZZLE
-3 TO -10°C
6-MINUTE RATE EVERY MINUTE
1996-1997 to 2004-2005
Cumulative Probability
Precipitation Rate (g/dm²/h)

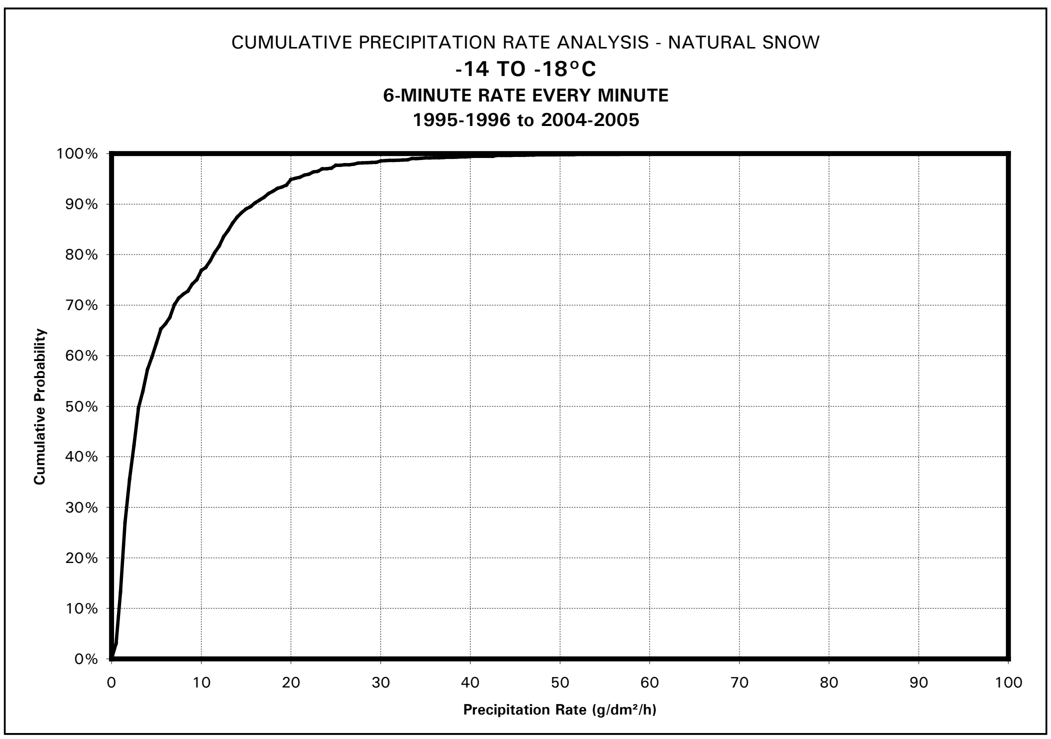

PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-14 TO -18°C
35-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
# of Occurrences
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)

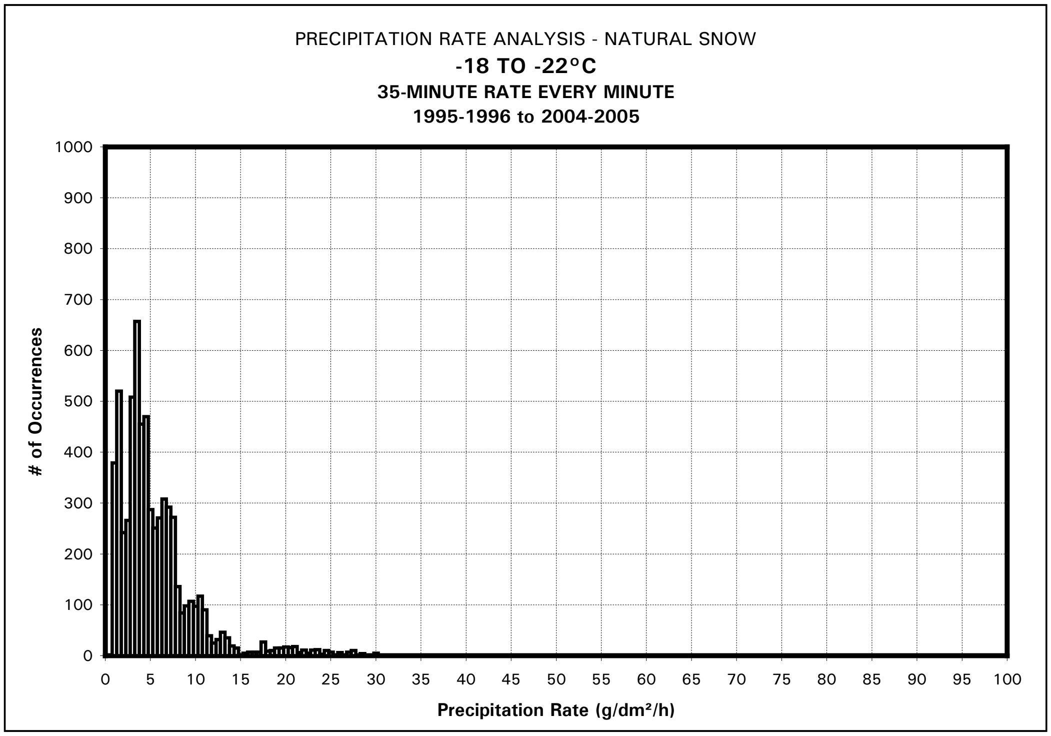

CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-14 TO -18°C
35-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
Cumulative Probability
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0 10 20 30 40 50 60 70 80 90 100
Precipitation Rate (g/dm²/h)

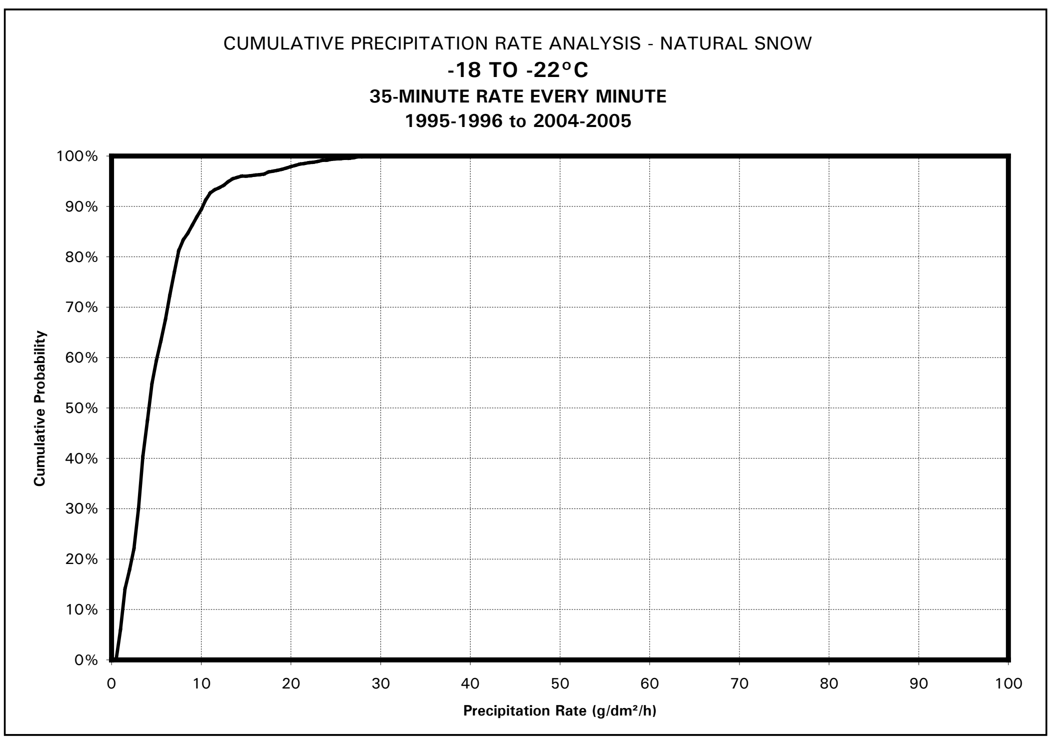

PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-14 TO -18°C
20-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
# of Occurrences
Precipitation Rate (g/dm²/h)

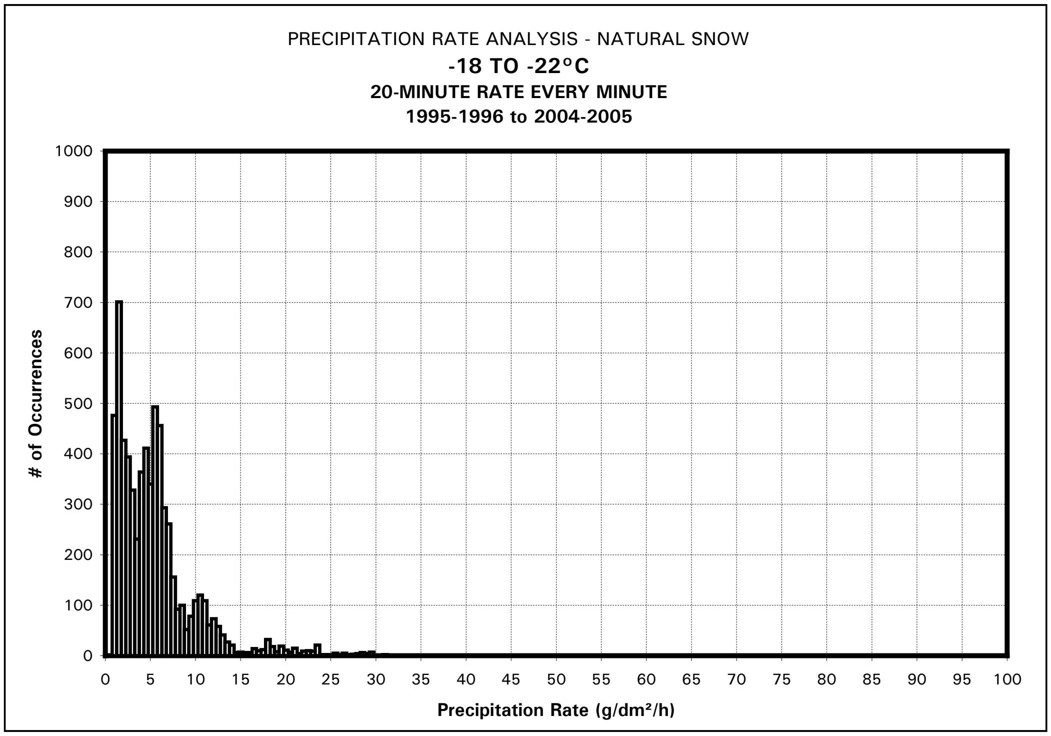

CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-14 TO -18°C
20-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
Cumulative Probability
Precipitation Rate (g/dm²/h)

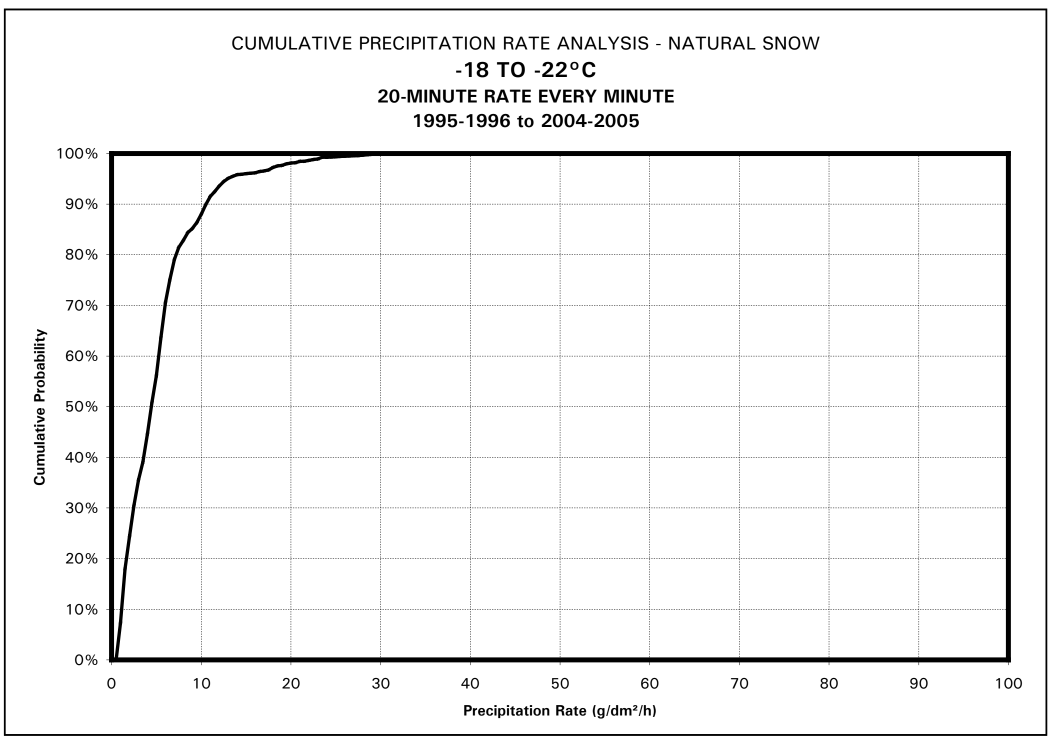

PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-14 TO -18°C
6-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
# of Occurrences
0
200
400
600
800
1000
1200
1400
1600
1800
2000
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)


CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-14 TO -18°C
6-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
Cumulative Probability
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
0 10 20 30 40 50 60 70 80 90 100
Precipitation Rate (g/dm²/h)


PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-18 TO -22°C
35-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
# of Occurrences
Precipitation Rate (g/dm²/h)


CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-18 TO -22°C
35-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
Cumulative Probability
Precipitation Rate (g/dm²/h)


PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-18 TO -22°C
20-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
# of Occurrences
0
100
200
300
400
500
600
700
800
900
1000
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)


CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-18 TO -22°C
20-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
Cumulative Probability
0%
10%
20%
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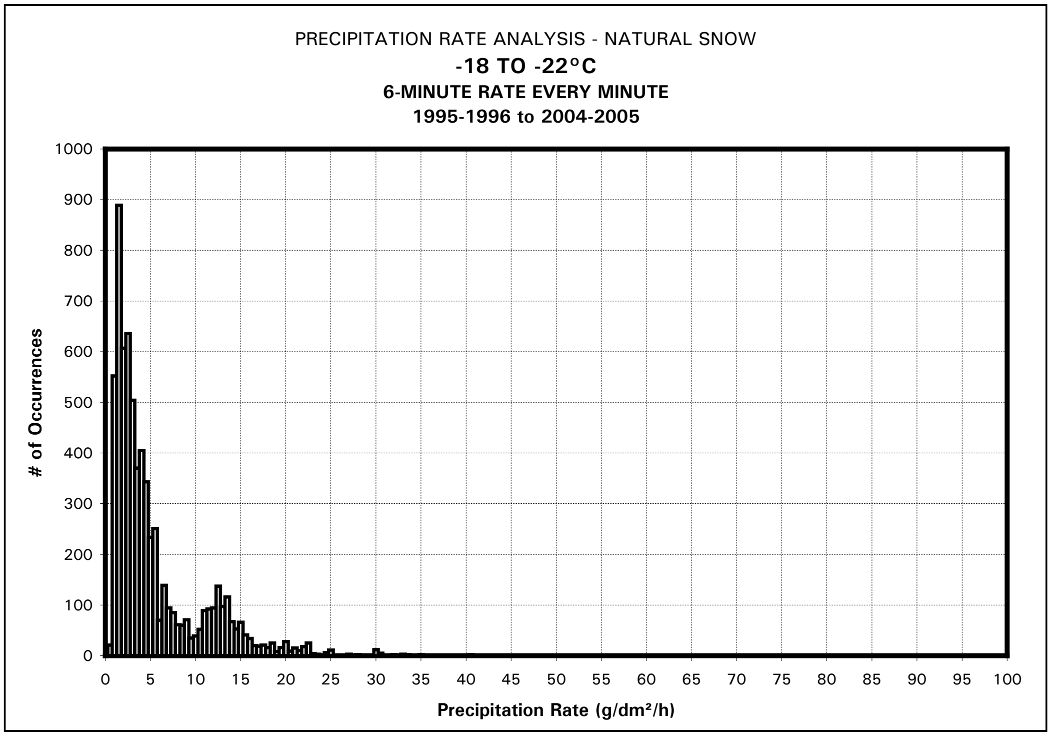
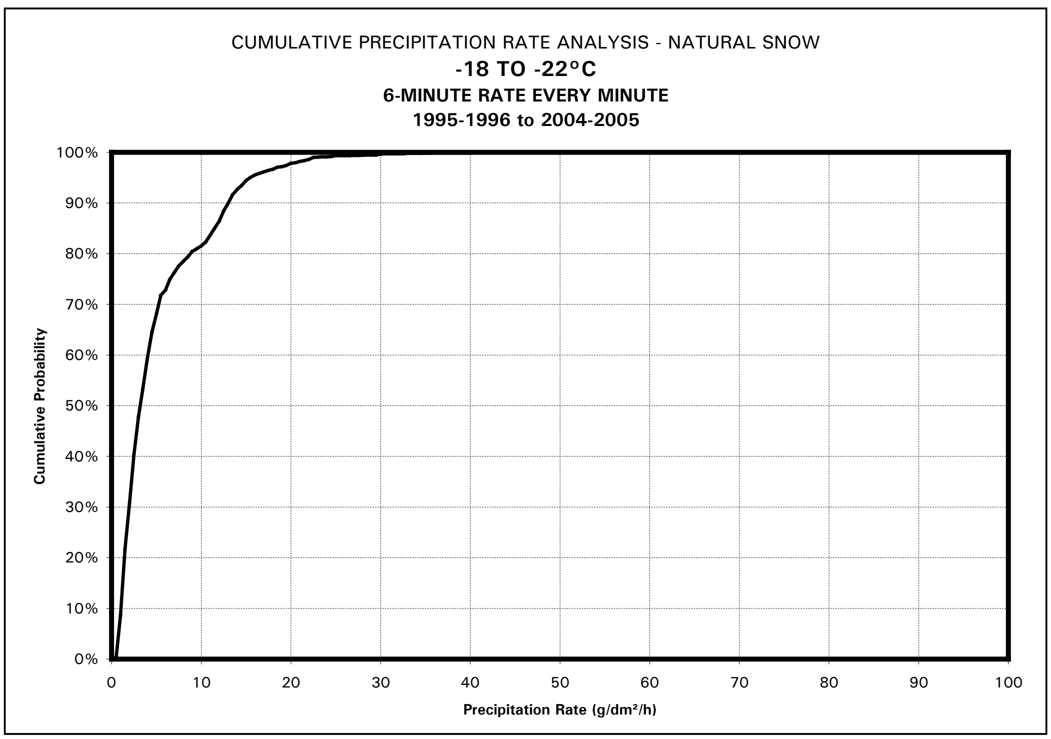
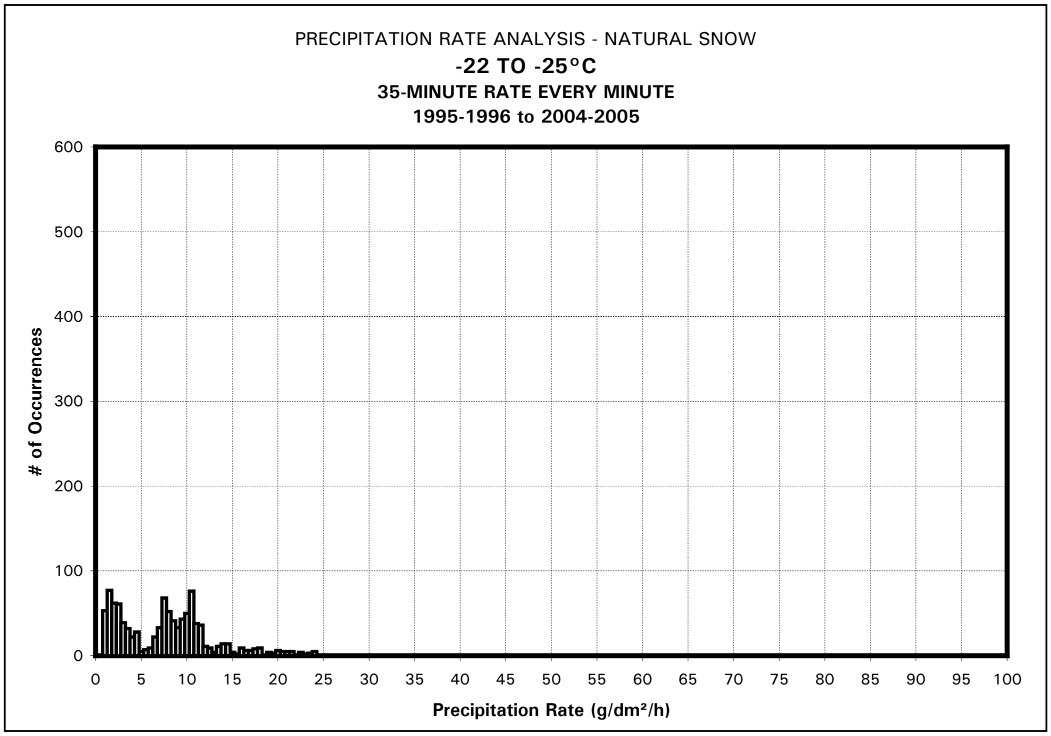
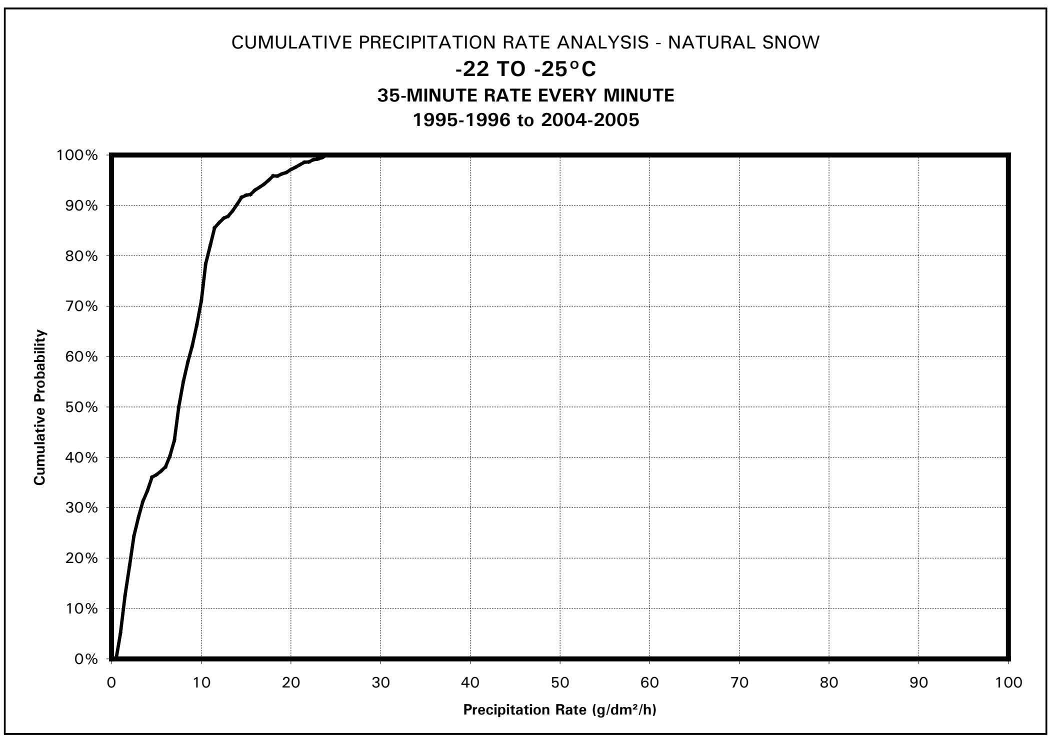

PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-18 TO -22°C
6-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
# of Occurrences
0
100
200
300
400
500
600
700
800
900
1000
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)


CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-18 TO -22°C
6-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
Cumulative Probability
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
0 10 20 30 40 50 60 70 80 90 100
Precipitation Rate (g/dm²/h)


PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-22 TO -25°C
35-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
# of Occurrences
0
100
200
300
400
500
600
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)


CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-22 TO -25°C
35-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
Cumulative Probability
0%
10%
20%
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60%
70%
80%
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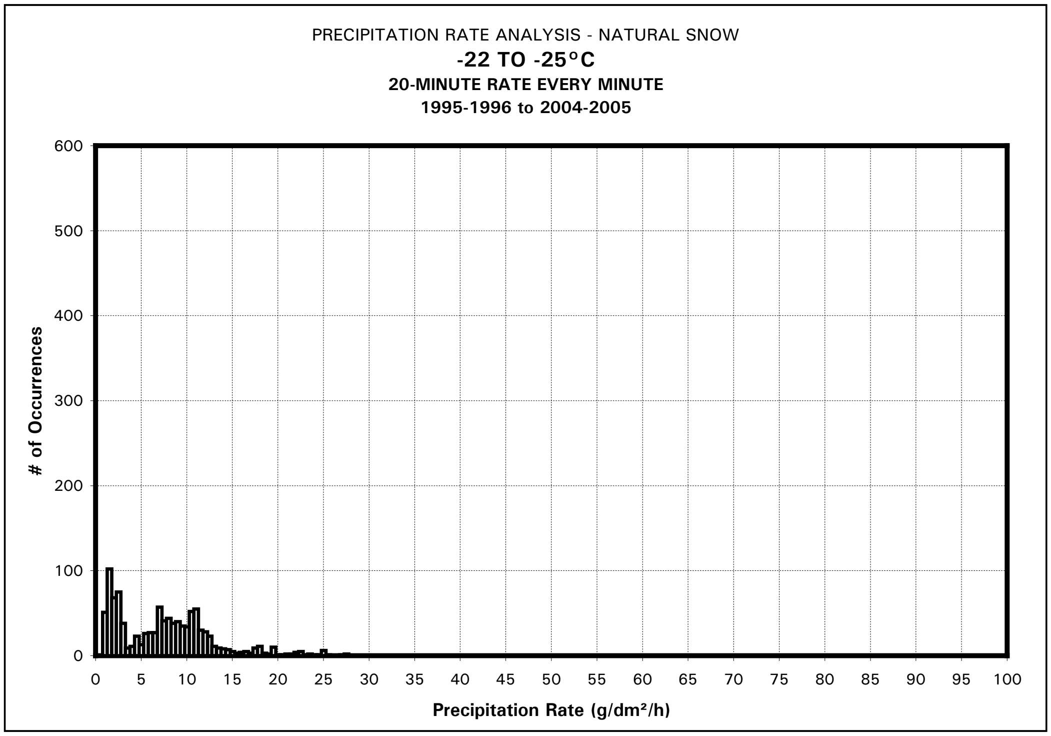
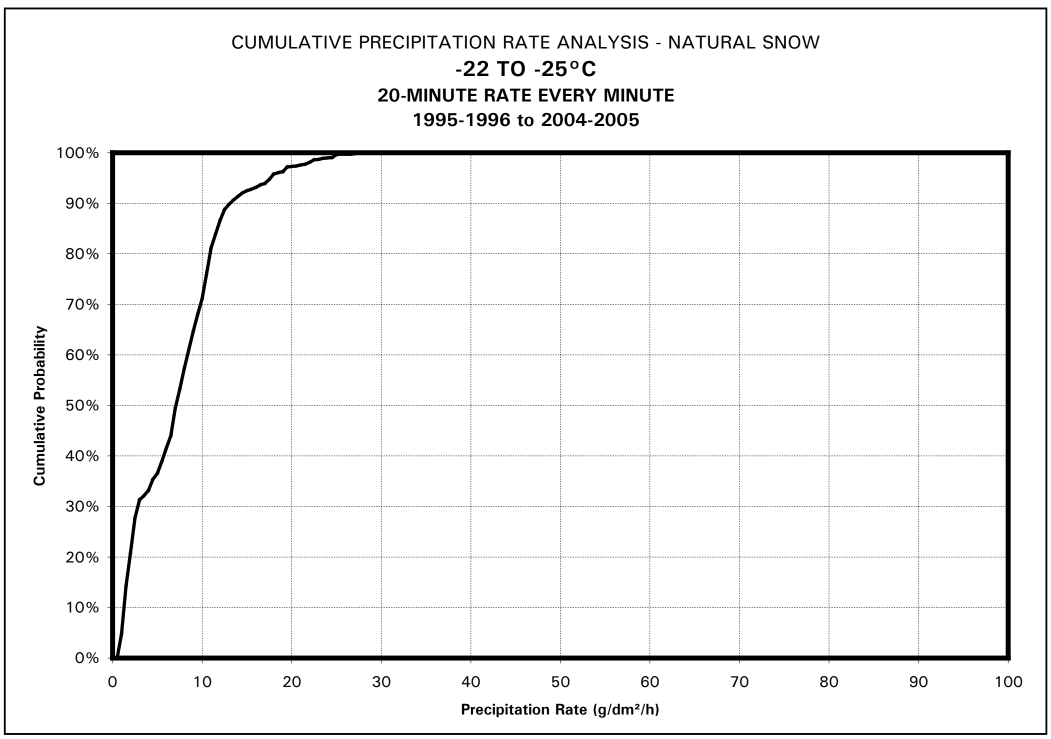
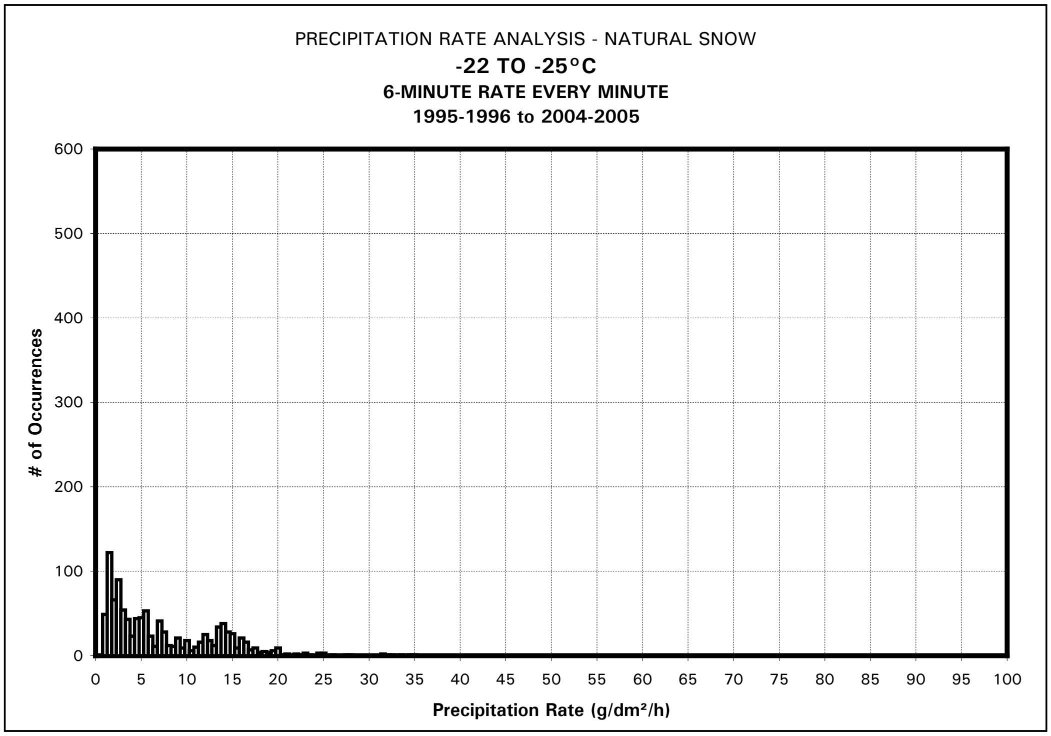
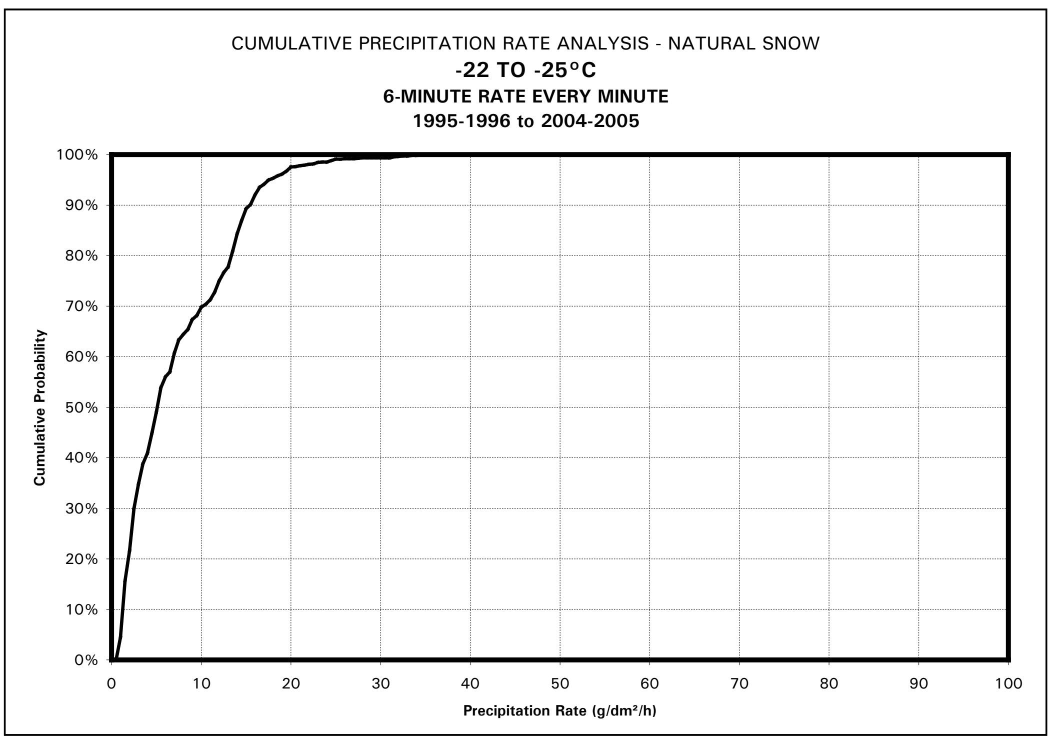
0 10 20 30 40 50 60 70 80 90 100
Precipitation Rate (g/dm²/h)


PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-22 TO -25°C
20-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
# of Occurrences
0
100
200
300
400
500
600
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)


CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-22 TO -25°C
20-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
Cumulative Probability
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
0 10 20 30 40 50 60 70 80 90 100
Precipitation Rate (g/dm²/h)


PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-22 TO -25°C
6-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
# of Occurrences
Precipitation Rate (g/dm²/h)


CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-22 TO -25°C
6-MINUTE RATE EVERY MINUTE
1995-1996 to 2004-2005
Cumulative Probability
Precipitation Rate (g/dm²/h)

APPENDIX C

CR21X AUTOMATIC DATA ACQUISITION STATION

CR21X Automatic Data Acquisition Station

Source: Most of the info was researched and obtained from various web sites.

Observations of hourly precipitation amount are extremely useful tools for diagnostic and research purposes. In Canada, such observations are made at a number of sites, the most common being from Meteorological Service of Canada stations around the country.

The meteorological station at Dorval Airport (Photo 1) uses a Fisher/Porter (500 mm) precipitation gauge as a precipitation gauge and also a tipping bucket rain gauge.

Photo 1

The Fisher/Porter (F&P) precipitation gauge, developed by the Belfort instrument Company (Photo 2), is designed to work for many years in remote and harsh environments. The F&P gauge weighs the precipitation it collects in a large metal bucket. This bucket sits atop a mechanism that records the amount of precipitation (Photo 3). The recording & transmitting precipitation gauge converts the weight of collected precipitation into the equivalent depth of accumulated water in conventional units of inches or millimeters. An 8-inch (20.3cm) diameter, knife-edge orifice collects all forms of precipitation. Rain travels through a funnel into the galvanized weighing bucket. The funnel is removed during the winter season to collect snow. When sub-freezing temperatures are expected, the bucket is partially filled with an antifreeze compound, which allows snow and ice to melt and be accurately measured. A weighing transducer provides instantaneous displacement values of the bucket in terms of millimeters of precipitation. This shaft displacement is transmitted every 5 seconds and averaged every minute in an attempt to eliminate spurious data caused by gusts of wind and temperature-induced contraction and expansion of the sensor. The readings are automatically logged with a CR21X data logger. The CR21X station has an accuracy of 0.1 mm (1 g/dm²).

Photo 2

Photo 3

Precipitation rates tend to fluctuate rapidly during snowstorms. The data from the CR21X station required less smoothing before it could be interpreted. The increased resolution of the CR21X weighing transducer allows better observation of short periods with heavy precipitation.

APPENDIX D

EXAMPLE OF MONTHLY METEOROLOGICAL SUMMARY MONTREAL - DORVAL

ENVIRONNEMENT CANADA
SERVICE MÉTÉOROLOGIQUE DU CANADA
ENVIRONMENT CANADA
METEOROLOGICAL SERVICE OF CANADA

SOMMAIRE MÉTÉOROLOGIQUE MENSUEL
MONTHLY METEOROLOGICAL SUMMARY

Montreal/P E Trudeau Int'l A

FEVRIER 2005
FEBRUARY 2005

LAT : 45°28 N ALTITUDE : 35.7 MÈTRES (NMM) HEURE NORMALE UTILISÉE : DE L'EST
LONG : 73°45 W ÉLÉVATION : 35.7 MÈTRES (ASL) STANDARD TIME USED : EASTERN

DATE	Température / Temperature: Maximale / Maximum °C	Minimale / Minimum °C	Moyenne / Mean °C	Degrés-jours / Degree-days: De chauffe / Heating Base 18°C	De croissance / Growing Base 5°C	De réfrigération / Cooling Base 18°C	Humidité rel. / Rel. humidity: Maximale / Maximum %	Minimale / Minimum %	Orage / Thunderstorm	Précipitations / Precipitation: Pluie (hauteur) / Rainfall mm	Neige (hauteur) / Snowfall cm	Précip. totale / Total precip mm	Neige au sol / Snow on ground cm	Vents / Winds: Vitesse moyenne / Average speed Km/h	Direction dominante / Prevailing direction	Vitesse moyenne max sur 2 min et direction / Max 2 min mean speed and direction Km/h		Insolation effective / Bright sunshine Heures / Hours
1	-3.4	-16.8	-10.1	28.1			91	51					6	5.8	SW	SW*	11	5.4
2	-0.7	-8.5	-4.6	22.6			85	61					6	5.9	NNE	NNE*	11	4.1
3	-1.1	-10.5	-5.8	23.8			89	66					6	8.3	N	NNE*	13	2.2
4	3.3	-10.8	-3.8	21.8			85	47					6	5.1	SW	SW*	11	9.0
5	1.3	-7.4	-3.1	21.1			93	66					4	5.5	SSW	SW*	11	8.1
6	4.6	-8.0	-1.7	19.7			93	63					3	7.7	NNE	ENE*	13	5.2
7	6.4	-3.3	1.6	16.4			86	50					2	3.3	NNE*	NNE	11	
8	4.2	1.4	2.8	15.2			97	64		2.2		2.2	1	7.1	SSE	W*	15	
9	2.0	-4.2	-1.1	19.1			96	61			1.0	1.0	TR	14.5	W	NE	31	
10	-4.2	-9.1	-6.7	24.7			92	46			9.8	9.8	2	30.9	NNE	NNE	46	
11	0.1	-12.1	-6.0	24.0			66	39					6	19.1	W	WNW	33	9.6
12	0.3	-7.7	-3.7	21.7			89	63			0.2	0.2	6	17.4	W	W*	31	2.9
13	-3.7	-12.9	-8.3	26.3			83	53			1.0	1.0	6	12.2	SW	SW	24	9.8
14	2.1	-13.0	-5.5	23.5			88	54		0.2	1.0	1.2	6	22.9	E	SE	43	0.6
15	4.0	1.7	2.9	15.1			95	76		0.6	TR	0.6	4	19.9	SW	SW	41	
16	3.4	-7.9	-2.3	20.3			99	75		3.6	9.4	13.0	TR	11.5	N*	NW*	19	
17	-1.8	-11.3	-6.6	24.6			88	52			TR	TR	6	6.8	W*	NW	15	9.5
18	-6.2	-16.8	-11.5	29.5			92	60			4.2	4.2	9	18.7	WSW	WSW	35	1.2
19	-5.0	-19.4	-12.2	30.2			93	47			0.4	0.4	8	16.1	SW	SW	26	6.0
20	-12.1	-19.6	-15.9	33.9			57	37					7	11.2	W*	NNW	19	10.0
21	-4.9	-14.6	-9.8	27.8			90	50			9.6	9.6	7	20.6	NE	NE*	30	
22	-2.1	-8.7	-5.4	23.4			91	71			0.4	0.4	9	8.0	SW	WNW	13	2.4
23	-5.8	-15.0	-10.4	28.4			84	56					9	13.5	W	WSW*	24	9.9
24	-8.3	-20.8	-14.6	32.6			88	45					9	8.6	NE	NE	17	7.2
25	-5.2	-15.7	-10.5	28.5			83	36					9	10.2	NNE	NNE	20	9.9
26	-2.0	-18.7	-10.4	28.4			80	39					9	6.2	W	SW*	15	8.7
27	-5.2	-14.8	-10.0	28.0			65	39					9	18.3	W	W	33	10.3
28	-5.3	-14.7	-10.0	28.0			67	44					9	19.8	NE	NE*	31	0.4
	MOY / MEAN -1.6	MOY / MEAN -11.4	MOY / MEAN -6.5	TOTAL 686.7	TOTAL	TOTAL	MOY / MEAN 86	MOY / MEAN 54	TOTAL	TOTAL 6.6	TOTAL 37.0	TOTAL 43.6		MOY / MEAN 12.7	DOMINANTE / PREVALING W	MAXIMALE / MAXIMUM NNE	46	TOTAL 132.4
NORMALE / NORMAL	-4.3	-13.4	-8.9	758.2	0.9	0.0			0	18.4	43.8	59.7		15.0	WSW			123.9

SOMMAIRE DE DEGRÉS-JOURS / DEGREE-DAY SUMMARY

	Au-dessous de 18 °C / Below 18 °C: Année en cours / This year	Normale / Normal		Au-dessus de 5 °C / Above 5 °C: Année en cours / This year	Normale / Normal
Total du mois / Total for month	686.7	758.2	Total du mois / Total for month		0.9
Accumulés depuis le 1er juillet / Accumulated since July 1st	3207.0	3370.2	Accumulés depuis le 1er avril / Accumulated since April 1st	2141.5	2066.9

Jours avec précipitations totales / Days with total precipitation (mm): 0,5 ou plus / or more	1,0 ou plus / or more	2,0 ou plus / or more	10,0 ou plus / or more	50,0 ou plus / or more	Jours avec chutes de neige / Days with snowfall (cm): 0,2 ou plus / or more	1,0 ou plus / or more	2,0 ou plus / or more	10,0 ou plus / or more	50,0 ou plus / or more
9	8	5	1		10	7	4		

Canada

1. Normale/Normal 1971-2000
2. Journée climatologique/Climatological Day (01h00HNE à/to 01h00HNE)
3. (AUTO) : mesures d'une station automatique/data from automatic station
4. TR = Trace M = Manquant/Missing E = Estimé/Estimated C = Calme/Calm
5. Pas de valeur/No entry = Pas d'événement/No occurence
6. * = Indique la première de plusieurs valeurs valides/indicates first of many valid values
7. c = correction

Données horaires non controlées
Hourly data not validated
Les précipitations ont un seuil mesurable de 1,0 mm
Measurable threshold of precipitation is 1,0 mm

Creation : 4 MARS 20
Created : MARCH 4 20

RELEVÉS COMPARATIFS À : COMPARATIVE RECORDS AT :		Montreal/P E Trudeau Int'l A										FEVRIER 2005 FEBRUARY 2005	
	UNITÉS UNITS	CE MOIS-CI THIS MONTH		ANNÉE PRÉCÉDENTE PREVIOUS YEAR		NORMALE NORMAL	RECORD POUR LE MOIS RECORD FOR THE MONTH — MAXIMUM ABSOLU HIGHEST EVER			MINIMUM ABSOLU LOWEST EVER			DEPUIS SINCE
		RELEVÉ VALUE	JOUR DAY	RELEVÉ VALUE	JOUR DAY		RELEVÉ VALUE	JOUR DAY	ANNÉE YEAR	RELEVÉ VALUE	JOUR DAY	ANNÉE YEAR	
TEMPÉRATURE MAXIMALE HIGHEST TEMPERATURE (MAXIMUM)	°CELSIUS	6.4	7	5.5	29		15.0	22	1981				1941
TEMPÉRATURE MINIMALE LOWEST TEMPERATURE (MINIMUM)	°CELSIUS	-20.8	24	-24.0	15					-33.9	15	1943	1941
TEMPÉRATURE MENSUELLE MOYENNE MEAN MONTHLY TEMPERATURE	°CELSIUS	-6.5		-7.9		-8.9	-1.6		1981	-14.1		1993	1941
HAUTEUR TOTALE MENSUELLE DE PLUIE TOTAL MONTHLY RAINFALL	mm	6.6		2.8		18.4	87.0		1981	0.0		1993	1941
HAUTEUR TOTALE MENSUELLE DE NEIGE TOTAL MONTHLY SNOWFALL	cm	37.0		37.2		43.8	132.4		1960	11.4		1978	1941
PRÉCIPITATION TOTALE MENSUELLE TOTAL MONTHLY PRECIPITATION	mm	43.6		39.6		59.7	174.5		1960	7.7		1978	1941
NOMBRE DE JOURS AVEC PRÉCIPITATION MESURABLE NO OF DAYS WITH MEASURABLE PRECIPITATION		12		12		14	21		1960	2		1984	1941
HAUTEUR DE PLUIE MAXIMALE EN UNE JOURNÉE GREATEST RAINFALL IN ONE DAY	mm	3.6	16	1.4	21		31.5	25	1961				1941
HAUTEUR DE NEIGE MAXIMALE EN UNE JOURNÉE GREATEST SNOWFALL IN ONE DAY	cm	9.8	10	13.2	3		39.4	16	1954				1941
PRÉCIPITATION MAXIMALE EN UNE JOURNÉE GREATEST PRECIPITATION IN ONE DAY	mm	13.0	16	14.2	3		39.4	16	1954				1941
HAUTEUR DE PLUIE ENREGISTRÉE EN : MAXIMUM RAINFALL RECORDED IN :													
5 MINUTES	mm						1.0	24	1975				de/from
10 MINUTES	mm						1.3	9	1990				1943
15 MINUTES	mm						5.0	16	1983				à/to
30 MINUTES	mm						5.0	16	1983				1990
60 MINUTES	mm						5.3	22	1974				
24 HEURES CONSÉCUTIVE CONSECUTIVE HOURS	mm												
VITESSE MOYENNE DU VENT MEAN WIND SPEED	KM/H	12.7		17.2		15.0	22.2		1976	10.9		1987	1953
VITESSE MAXIMALE (MOYENNE SUR 2 MIN.) MAXIMUM SPEED (2 MIN. MEAN)	KM/H	NNE 46	10	WSW 54	4		NNE 80	26	1961				1953
POINTE DE VENT MAXIMALE MAXIMUM GUST SPEED	KM/H	NNE 61	10	WSW 69	4		WSW 138	25	1956				1955
TOTAL DES HEURES INSOLATION TOTAL HOURS OF SUNSHINE	HEURES	132.4		157.3		123.9	205.6		1987	73.7		1981	1969
PRESSION MOYENNE À LA STATION MEAN STATION PRESSURE	kPa	101.58		101.59		101.27	101.91		1955	100.31		1958	1953
PRESSION MAXIMALE À LA STATION GREATEST STATION PRESSURE	kPa	103.24	2	103.56	17		104.67	13	1981				1953
PRESSION MINIMALE À LA STATION LEAST STATION PRESSURE	kPa	99.50	12	99.33	21					96.58	25	1956	1953

DONNÉES CLIMATOLOGIQUES CE MOIS-CI POUR LES 10 DERNIÈRES ANNÉES
CLIMATOLOGICAL DATA THIS MOUNTH FOR THE PAST 10 YEARS

ANNÉE YEAR	TEMPÉRATURE MAXIMALE MAXIMUM TEMP.	TEMPÉRATURE MINIMALE MINIMUM TEMPERATURE	TEMPÉRATURE MOYENNE MEAN TEMPERATURE	HAUTEUR DE PLUIE RAINFALL	HAUTEUR DE NEIGE SNOWFALL	PRÉCIPITATION TOTALE TOTAL PRECIPITATION	VITESSE MOYENNE DES VENTS MEAN WIND SPEED	VITESSE MAXIMALE DES VENTS MAXIMUM WIND SPEED	HEURES D'ENSOLEILLEMENT SUNSHINE HOURS	DEGRÉS-JOURS DE CHAUFFE HEATING DEGREE-DAYS	DEGRÉS-JOURS DE CROISSANCE GROWING DEGREE-DAYS	DEGRÉS-JOURS DE RÉFRIGÉRATION COOLING DEGREE-DAYS	A.S.N S.A.S
1996	7.5	-23.6	-7.9	52.4	17.4	72.7	14.9	WNW 52	133.3	752.3			176.1
1997	8.2	-28.3	-7.9	35.9	70.5	96.4	14.2	SW 50	106.4	725.3			206.3
1998	5.9	-19.7	-3.8	16.5	27.2	63.8	12.5	W 39	137.5	610.7			190.4
1999	9.1	-19.0	-5.1	20.6	15.5	44.3	13.2	SSE 41	152.8	647.1			122.8
2000	10.9	-21.6	-7.0	8.2	67.1	73.0	18.0	SW 54	149.3	725.4	2.2		154.8
2001	8.8	-23.3	-8.7	30.1	44.0	74.2	18.0	W 76	114.5	747.0			188.6
2002	11.4	-18.8	-5.0	18.2	19.0	41.2	18.5	SW 67	105.3	643.3	1.0		94.8
2003	4.1	-25.9	-10.8	19.0	31.9	62.8	19.4	WSW 63	149.7	805.6			131.9
2004	5.5	-24.0	-7.9	2.8	37.2	39.6	17.2	WSW 54	157.3	750.8			137.0
2005	6.4	-20.8	-6.5	6.6	37.0	43.6	12.7	NNE 46	132.4	686.7			128.4

Avis / Note :

*	:	Nouveau record / New record
#	:	Station manuelle / Manual station
A.S.N	:	Accumulation Saisonnière de Neige / S.A.S = Season Accumulation Snowfall

TEMPÉRATURE / TEMPERATURE

TEMPÉRATURE HORAIRE
HOURLY TEMPERATURE

Montreal/P E Trudeau Int'l A

FEVRIER 2005
FEBRUARY 2005

DATE	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	-119	-141	-146	-137	-147	-154	-151	-138	-136	-138	-99	-86	-65	-54	-40	-36	-41	-44	-39	-35	-40	-43	-46	-41
2	-47	-45	-48	-49	-54	-56	-57	-58	-55	-47	-34	-30	-27	-20	-15	-10	-9	-11	-21	-32	-46	-32	-60	-73
3	-79	-84	-88	-91	-98	-92	-99	-100	-98	-89	-67	-50	-44	-32	-22	-17	-17	-23	-29	-35	-36	-38	-43	-50
4	-46	-50	-53	-79	-62	-76	-72	-103	-85	-64	-36	-16	2	15	19	19	22	10	2	-11	-34	-34	-30	-43
5	-65	-63	-64	-68	-63	-68	-59	-67	-58	-46	-31	-8	-2	10	10	11	3	-1	-19	-31	-30	-39	-46	-41
6	-51	-59	-59	-47	-68	-57	-58	-43	-57	-27	-16	-7	18	17	32	22	19	16	5	-3	-10	-13	-12	-14
7	-15	-18	-22	-25	-24	-24	-25	-25	-15	-3	20	32	44	53	60	54	55	45	36	39	35	33	30	34
8	32	29	27	24	40	21	18	15	16	18	20	26	25	24	18	32	26	25	24	27	25	23	21	21
9	22	19	16	12	7	3	1	-3	-3	-7	-10	-13	-10	-6	-3	-9	-13	-13	-10	-3	-5	-11	-19	-25
10	-34	-42	-46	-51	-51	-53	-57	-58	-60	-61	-60	-59	-57	-57	-45	-54	-54	-54	-52	-50	-50	-42	-53	-59
11	-84	-85	-81	-96	-97	-104	-112	-108	-106	-90	-67	-52	-15	-4	-2	-6	-9	-14	-29	-39	-48	-52	-56	-56
12	-67	-67	-75	-70	-62	-56	-54	-46	-43	-37	-29	-21	-12	-3	-2	1	1	-3	-3	-14	-32	-27	-25	-28
13	-26	-37	-50	-66	-75	-87	-106	-122	-123	-111	-103	-98	-88	-85	-78	-73	-77	-77	-86	-91	-97	-102	-104	-117
14	-120	-120	-114	-111	-111	-124	-119	-126	-112	-102	-89	-59	-49	-39	-22	-18	-10	-3	0	4	9	11	15	16
15	18	18	20	22	23	25	33	28	28	27	31	35	37	33	33	32	28	37	33	35	33	35	32	26
16	26	27	23	24	22	23	23	19	12	5	3	3	2	3	3	6	8	2	-3	-11	-17	-25	-32	-52
17	-69	-72	-79	-86	-88	-97	-112	-107	-98	-80	-71	-65	-61	-52	-31	-30	-43	-49	-59	-65	-68	-68	-65	-71
18	-67	-68	-64	-66	-74	-90	-86	-87	-84	-91	-94	-89	-108	-111	-118	-110	-118	-122	-129	-131	-137	-144	-147	-154
19	-163	-168	-169	-174	-178	-179	-182	-190	-177	-156	-140	-121	-106	-87	-78	-66	-57	-52	-56	-58	-60	-75	-91	-101
20	-116	-125	-132	-151	-159	-161	-182	-189	-165	-157	-152	-142	-137	-133	-131	-127	-126	-126	-127	-130	-142	-139	-135	-134
21	-127	-123	-133	-142	-143	-145	-145	-143	-143	-135	-122	-102	-75	-63	-61	-57	-51	-51	-80	-91	-88	-85	-86	-90
22	-88	-87	-86	-85	-86	-84	-81	-80	-79	-72	-66	-55	-51	-41	-36	-27	-22	-26	-29	-58	-60	-56	-63	-51
23	-54	-62	-71	-80	-92	-122	-131	-135	-124	-121	-115	-108	-98	-97	-90	-85	-82	-83	-90	-100	-108	-120	-140	-143
24	-131	-134	-143	-156	-161	-156	-178	-189	-174	-134	-104	-100	-97	-89	-88	-87	-88	-93	-95	-93	-107	-102	-104	-117
25	-119	-123	-131	-139	-147	-147	-146	-151	-142	-126	-119	-108	-94	-85	-76	-72	-55	-71	-81	-85	-95	-105	-121	-118
26	-134	-147	-154	-158	-152	-157	-180	-160	-153	-131	-106	-90	-69	-64	-50	-46	-52	-54	-65	-67	-76	-97	-109	-108
27	-123	-112	-134	-125	-120	-123	-120	-123	-116	-109	-97	-92	-83	-74	-63	-59	-54	-56	-70	-77	-84	-90	-103	-112
28	-109	-114	-116	-124	-137	-108	-105	-99	-92	-80	-70	-65	-62	-58	-60	-60	-61	-59	-59	-61	-62	-62	-63	-60
29																								
30																								
31																								

Avis / Note : Unités / Units: 0.1 °C M = Manquant / Missing

Lire / Read -123 = -12.3 °C -1 = -0.1 °C 0 = 0.0 °C 12 = +1.2 °C 123 = 12.3 °C

Heure normale locale : Est
Local standard time: Eastern

Si vous avez des questions, commentaires ou désirez recevoir de l'information sur les produits offerts pas Environnement Canada :
If you have questions, comments or wish information on products offered by Environment Canada:

Écrivez-nous à : *Write to us at :*

ENVIRONNEMENT CANADA / ENVIRONMENT CANADA
Services climatologiques et de qualité de l'air / Climate and Air Quality Services
100 Alexis Nihon, 3e
Ville St-Laurent, QC - H4M 2N8 Télécopieur / Fax : (514) 283-2264
Courrier éléctronique / Email : *Climat.Quebec@ec.gc.ca*
Renseignements climatologiques / Climate Information : 1-900-565-1111 (2,99 $ / minute)

VENTS / WINDS

VENTS HORAIRES (KM/H)
HOURLY WINDS (KM/H)

Montreal/P E Trudeau Int'l A

FEVRIER 2005
FEBRUARY 2005

DATE	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	RAFALE MAX / PEAK GUST	Heure / Time	Jour / Day
1	C 0	W 4	SSW 7	SW 11	C 0	N 4	C 0	SSW 11	SW 11	C 0	SSW 9	S 6	S 4	SW 4	SW 6	SSW 7	SW 11	SW 6	SSW 7	SSW 6	SW 9	SSW 7	SW 4	SW 4			
2	C 0	SW 6	SW 6	SW 7	SW 4	C 0	C 0	C 0	C 0	C 0	C 0	N 4	N 6	NNE 7	NNE 7	NNE 11	NNE 11	NE 11	NE 11	NNE 7	N 6	NE 11	NNE 7	N 7			
3	N 9	NNE 9	N 7	NNE 9	N 4	ENE 4	N 9	NNE 13	NE 13	NE 11	NNE 9	NNE 7	N 9	N 7	NNE 9	N 7	NNW 6	N 7	NNE 11	NNE 9	N 11	N 9	N 9	NNE 6			
4	N 7	N 7	C 0	C 0	NNE 6	NNW 7	C 0	C 0	NW 6	NNW 4	NNW 6	N 4	SW 4	WSW 4	SW 11	WSW 9	SW 9	WSW 7	SW 11	SW 11	SSW 7	C 0	W 4	SSW 7			
5	C 0	SW 6	SSW 7	S 7	SSW 9	SSW 7	WSW 7	W 7	W 4	NW 6	C 0	S 4	SSW 4	SW 7	SW 11	SSW 7	SW 11	SW 9	S 4	W 4	SE 4	C 0	C 0	ENE 6			
6	WNW 4	N 4	N 4	C 0	NE 6	N 7	N 11	ENE 13	N 6	C 0	NE 6	NNE 9	NE 7	ESE 6	ENE 6	NNE 11	NNE 9	NE 9	N 6	N 9	NNE 11	NNE 13	NNE 11	NNE 11			
7	N 6	NNE 7	NNE 9	NNW 9	NNE 11	N 6	C 0	C 0	C 0	C 0	C 0	C 0	C 0	SSE 4	SSW 6	S 7	C 0	SW 4	C 0	S 4	C 0	C 0	C 0	ESE 6			
8	ENE 6	ESE 6	C 0	C 0	NNE 7	C 0	N 7	N 6	C 0	SE 4	SSE 7	SSE 4	WNW 4	SSE 13	SE 4	SSW 11	SSE 4	WNW 4	SSE 13	SSE 9	W 15	WSW 13	SW 9	W 9			
9	W 15	W 13	W 17	W 19	W 19	W 17	W 13	W 13	W 13	W 15	WNW 15	W 6	NW 7	WNW 4	NNE 11	ESE 6	SSW 9	C 0	C 0	ENE 13	ENE 17	NE 26	NE 26	NE 31	NE 37	1	10
10	NE 26	NE 24	NNE 30	NE 33	NE 31	NNE 35	NNE 41	NNE 43	NE 39	NNE 46	NNE 44	NNE 35	NNE 35	NNE 39	NNE 35	NNE 33	NNE 33	NNE 26	NNE 30	N 19	N 15	N 28	N 24	N 19	NNE 61	9	10
11	NNW 13	NNW 15	NW 13	NW 13	NW 13	W 11	W 13	W 15	W 9	SW 17	WSW 15	SW 13	W 19	W 17	WNW 28	WNW 30	WNW 33	WNW 28	W 26	W 28	W 28	W 15	W 17	W 19	WNW 44	16	11
12	W 22	W 17	SSW 11	WSW 11	WSW 22	WSW 20	WSW 17	W 19	W 19	WSW 17	WSW 13	W 26	W 31	W 30	W 31	W 19	W 22	W 20	WSW 15	WNW 7	WNW 9	NW 9	WNW 11	WNW 9	W 33	12	12
13	NW 13	NW 17	NNW 17	NNE 17	NNE 15	NNW 22	NNW 13	NNW 9	NW 9	NNW 7	WNW 7	NW 7	W 9	SW 24	WSW 13	SW 20	SW 20	SW 15	SW 13	WSW 7	SW 11	SW 6	SW 9	SSW 9			
14	SSE 7	ESE 7	ESE 4	E 7	E 9	E 9	E 15	E 9	E 6	NE 20	NE 17	E 15	E 22	ESE 28	SE 26	SE 35	SE 43	SSE 35	SE 37	SSE 35	SSE 33	SSE 30	SSE 37	SSE 30	SE 57	16	14
15	SE 24	SSE 24	SSE 22	SSE 22	SSE 30	S 17	SW 28	SW 31	SW 41	WSW 28	WSW 30	WSW 31	SW 39	SW 22	SSW 20	SSW 11	SSW 11	WSW 4	SSW 11	SW 7	S 13	SSW 17	SSW 15	S 13	SW 56	8	15
16	S 9	SW 6	ESE 4	SE 6	C 0	N 9	N 13	N 7	NNW 13	N 11	NNW 13	N 11	WNW 9	W 11	WNW 13	WNW 15	W 15	NW 15	NW 15	NW 19	NNW 11	NNW 19	NW 17	WNW 13	NW 32	19	16
17	W 7	WNW 9	W 9	W 11	W 13	WNW 7	NW 15	N 4	N 7	C 0	C 0	NNE 7	C 0	NNE 4	NNW 4	WSW 9	WSW 6	S 7	SSE 9	SSE 13	SE 7	ESE 7	SE 9	SE 11			
18	E 4	C 0	ENE 4	C 0	NNE 9	N 7	N 4	W 6	WSW 19	WSW 24	WSW 24	WSW 24	WSW 30	WSW 33	WSW 35	WSW 26	W 28	WSW 28	WSW 26	W 26	WNW 19	W 19	W 15	W 15	WSW 44	14	18
19	W 13	W 15	WSW 11	WSW 9	SW 11	SW 13	W 17	W 7	W 11	SW 19	SW 19	SW 22	SW 19	SSW 20	SSW 17	SW 13	WSW 22	SW 26	SW 22	WSW 22	NW 17	NW 15	NW 13	NW 17	SW 33	18	19
20	NW 13	WNW 11	NNW 19	NW 9	NNW 9	N 15	N 7	NNW 7	NW 4	W 9	W 9	W 11	W 13	WSW 11	SW 17	SW 17	SSW 15	SW 9	SW 9	ESE 6	ESE 9	ESE 9	ESE 13	E 11			
21	E 15	NE 15	NE 19	NE 26	NE 28	NE 30	NE 30	NE 26	NE 30	NE 30	NE 24	NE 22	ENE 19	E 17	E 22	E 24	E 19	E 13	N 15	NNE 11	N 13	N 17	NNE 22	N 13	NE 39	6	21
22	N 11	N 13	N 9	WNW 9	W 9	W 7	SW 6	SW 9	SW 11	WSW 11	C 0	W 9	SSW 9	S 11	SW 11	SW 11	SW 9	WSW 7	W 9	WNW 4	W 7	C 0	SW 4	WNW 7			
23	NW 9	WNW 13	NW 11	WNW 13	NW 13	WNW 9	WNW 9	NW 7	N 7	NNW 13	WNW 11	W 15	W 13	WSW 24	W 22	W 24	W 22	W 22	WSW 17	W 20	W 13	W 15	W 9	WNW 9	W 33	14	23
24	NW 7	C 0	N 4	C 0	N 7	C 0	C 0	N 6	N 7	NNE 7	NE 7	E 7	NE 7	NE 6	NE 6	NE 11	ENE 11	E 13	NE 17	NE 9	NNE 13	ENE 15	NE 11	NNE 15			
25	NNE 13	NNE 15	NNE 15	NNE 15	NNE 13	NNE 17	NNE 13	NNE 19	NNE 17	NNE 20	NE 15	NNE 9	N 7	ENE 4	NE 9	ENE 6	C 0	SW 9	WSW 9	SW 11	WSW 6	WSW 4	WSW 6	SW 4			
26	SSW 7	SW 9	W 4	WSW 7	C 0	C 0	W 6	C 0	N 4	N 6	NNE 4	E 4	C 0	C 0	C 0	C 0	SW 13	SW 15	SW 13	SW 7	W 15	W 13	W 11	W 11			
27	W 7	W 9	W 11	W 9	W 15	W 15	W 17	WNW 15	WNW 24	W 22	W 22	WSW 26	W 28	W 33	W 26	W 28	W 28	W 24	WSW 24	WSW 19	W 19	WSW 6	ESE 6	WSW 4	W 44	14	27
28	WSW 7	SW 11	C 0	ENE 4	C 0	E 7	ESE 6	ESE 7	E 9	E 13	NE 24	NE 24	NE 22	ENE 24	NE 30	NE 26	NE 28	NE 30	NE 30	NE 31	NE 31	NE 30	NE 28	NE 26	NE 39	18	28
29																											
30																											
31																											

Avis / Note: C = Calme / Calm M = Manquant / Missing

Heure normale locale : Est
Local standard time : Eastern

HUMIDITÉ / HUMIDITY

POINTS DE ROSÉE HORAIRES / HOURLY DEW POINTS — Montreal/P E Trudeau Int'l A — FEVRIER 2005 / FEBRUARY 2005

DATE	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	-150	-163	-166	-152	-162	-168	-169	-155	-148	-159	-144	-137	-129	-132	-127	-123	-121	-109	-105	-101	-95	-89	-84	-90
2	-82	-85	-81	-91	-84	-82	-81	-79	-78	-75	-72	-71	-72	-71	-71	-66	-64	-76	-79	-80	-87	-84	-91	-96
3	-103	-108	-111	-113	-119	-109	-115	-115	-113	-105	-92	-86	-85	-80	-76	-71	-69	-74	-78	-85	-80	-82	-89	-91
4	-89	-93	-95	-108	-99	-105	-104	-123	-106	-95	-85	-92	-83	-84	-69	-74	-78	-86	-94	-86	-82	-88	-89	-91
5	-93	-88	-93	-96	-94	-97	-78	-79	-67	-59	-59	-55	-49	-44	-46	-45	-49	-51	-49	-58	-50	-59	-60	-58
6	-67	-74	-74	-60	-83	-67	-67	-58	-69	-47	-40	-39	-30	-30	-32	-24	-26	-28	-30	-33	-36	-40	-41	-41
7	-40	-43	-48	-46	-48	-47	-48	-45	-36	-25	-27	-26	-24	-20	-35	-26	-33	-26	-30	-27	-25	-23	-27	-23
8	-22	-15	-15	-14	-21	-9	-10	-7	1	1	5	17	-20	19	1	26	17	-20	19	22	21	18	16	17
9	18	14	10	3	-7	-13	-17	-21	-24	-31	-30	-29	-26	-29	-49	-32	-35	-36	-35	-67	-71	-64	-76	-81
10	-68	-59	-61	-68	-67	-70	-72	-74	-75	-77	-75	-72	-70	-71	-62	-67	-68	-65	-63	-64	-65	-104	-151	-132
11	-135	-141	-143	-148	-153	-163	-163	-162	-160	-149	-133	-123	-132	-120	-112	-125	-125	-134	-125	-118	-121	-125	-127	-130
12	-128	-128	-126	-115	-103	-95	-84	-64	-64	-60	-55	-57	-57	-58	-62	-61	-58	-57	-58	-51	-47	-54	-56	-56
13	-60	-80	-75	-91	-131	-145	-164	-167	-168	-165	-163	-160	-167	-149	-150	-143	-151	-156	-153	-156	-158	-157	-159	-152
14	-153	-156	-151	-148	-146	-145	-155	-155	-145	-150	-141	-136	-126	-108	-89	-85	-71	-63	-42	-23	-16	-9	-8	-5
15	-2	1	4	6	9	9	9	10	3	1	-2	-1	-2	-3	0	1	3	3	3	4	2	4	17	18
16	19	19	17	21	21	21	18	15	7	1	0	0	0	1	0	3	2	-3	-12	-31	-30	-60	-70	-80
17	-96	-101	-108	-109	-114	-120	-128	-126	-127	-122	-132	-137	-134	-120	-116	-108	-107	-97	-103	-118	-115	-110	-101	-106
18	-107	-105	-110	-90	-87	-105	-99	-98	-101	-118	-117	-114	-140	-137	-146	-148	-157	-160	-159	-175	-181	-195	-197	-201
19	-223	-223	-226	-227	-229	-229	-228	-232	-223	-217	-208	-202	-198	-172	-152	-128	-115	-109	-83	-68	-75	-131	-155	-185
20	-195	-199	-210	-230	-248	-253	-254	-253	-254	-244	-254	-254	-251	-247	-238	-238	-239	-227	-236	-231	-228	-224	-219	-219
21	-224	-219	-215	-219	-219	-198	-184	-179	-174	-162	-151	-126	-93	-76	-77	-75	-69	-69	-98	-107	-104	-101	-104	-107
22	-107	-105	-104	-105	-107	-105	-104	-101	-91	-91	-91	-86	-87	-83	-79	-70	-67	-66	-64	-79	-83	-75	-84	-70
23	-73	-90	-107	-117	-128	-147	-155	-156	-160	-175	-166	-167	-158	-160	-154	-155	-151	-155	-158	-156	-160	-167	-183	-179
24	-168	-169	-172	-180	-185	-183	-193	-214	-194	-166	-163	-181	-173	-173	-178	-181	-185	-183	-186	-190	-178	-192	-192	-179
25	-176	-182	-184	-191	-198	-212	-213	-213	-205	-187	-180	-177	-167	-169	-166	-162	-183	-154	-158	-153	-160	-157	-162	-156
26	-172	-169	-181	-193	-189	-192	-208	-187	-185	-177	-168	-202	-152	-161	-158	-165	-156	-162	-156	-161	-168	-167	-167	-165
27	-177	-178	-186	-185	-184	-186	-191	-197	-194	-194	-182	-185	-178	-175	-172	-177	-172	-170	-161	-152	-168	-172	-176	-189
28	-191	-190	-196	-192	-193	-165	-155	-154	-159	-163	-158	-160	-157	-159	-155	-163	-159	-162	-158	-156	-162	-165	-158	-150
29																								
30																								
31																								

Avis / Note: Unités / Units : 0,1 °C M = Manquant / Missing

HUMIDITÉS RELATIVES HORAIRES RELEVÉE À : / HOURLY RELATIVE HUMIDITIES AT :

DATE	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	78	83	85	88	88	89	86	87	91	84	70	66	60	54	51	51	54	60	60	60	65	70	75	69
2	76	74	78	72	79	82	83	85	84	81	75	73	71	68	66	66	66	61	64	69	73	67	79	84
3	83	83	83	84	85	87	88	89	89	88	82	76	73	69	66	66	68	68	69	68	71	71	70	73
4	72	72	72	80	75	80	78	85	85	79	69	56	53	48	52	50	47	49	48	57	69	66	64	69
5	80	82	80	80	79	80	86	91	93	91	81	70	71	67	66	66	68	69	80	82	86	86	90	88
6	88	89	89	91	89	93	93	89	91	86	84	79	70	71	63	72	72	72	77	80	82	82	81	82
7	83	83	82	85	84	84	84	86	86	85	71	66	61	59	50	56	53	60	62	62	65	67	66	66
8	68	73	74	76	64	80	82	85	90	88	90	94	72	96	88	96	94	72	96	97	97	96	96	97
9	97	96	96	94	90	89	88	88	86	84	86	89	89	84	71	84	85	84	83	62	61	67	65	65
10	77	88	89	88	88	88	89	88	89	88	89	90	90	90	88	91	90	92	92	90	89	62	46	56
11	66	64	61	66	63	62	66	64	64	62	59	57	40	41	43	40	41	39	47	54	56	56	57	56
12	62	62	67	70	73	74	79	87	85	84	82	76	71	66	64	63	64	67	66	76	89	82	79	81
13	77	72	83	82	64	63	62	69	69	64	61	60	53	60	56	57	55	53	58	59	61	64	64	75
14	76	74	74	74	75	84	74	79	76	68	66	54	55	59	60	60	63	64	73	82	83	86	85	86
15	87	88	89	89	90	89	84	88	84	83	79	77	76	77	79	80	84	78	81	80	80	80	90	94
16	95	94	96	98	99	99	96	97	96	97	98	98	99	99	98	98	96	96	94	86	91	77	75	81
17	81	80	80	83	81	83	88	86	79	72	62	56	56	59	52	55	61	69	71	66	69	72	75	76
18	73	75	70	83	90	89	90	92	87	81	83	82	77	81	80	73	73	73	78	69	69	65	66	67
19	60	62	61	63	64	65	67	69	67	59	56	51	47	50	55	61	63	64	81	93	89	64	60	50
20	52	54	52	51	46	45	53	57	46	47	41	38	37	37	40	39	38	42	39	42	48	48	49	49
21	44	44	50	52	52	64	72	74	77	80	79	82	87	90	88	87	87	87	87	88	88	88	87	87
22	86	87	87	85	85	85	83	85	91	86	82	79	76	72	72	72	71	74	77	85	84	86	85	86
23	86	80	75	75	75	82	82	84	74	64	66	62	61	60	60	57	57	56	58	63	65	68	70	74
24	74	75	78	82	82	80	88	80	84	77	62	51	54	50	48	46	45	48	47	45	56	47	48	60
25	62	61	64	65	65	57	57	59	59	60	60	57	55	51	48	48	36	51	54	58	59	65	71	73
26	73	83	80	74	73	74	79	80	76	68	60	40	51	46	42	39	44	42	48	47	48	56	62	63
27	64	58	65	61	59	59	55	54	52	49	50	47	46	44	42	39	39	40	48	55	51	51	55	53
28	51	53	51	57	62	63	67	64	58	51	49	47	47	45	47	44	46	44	45	47	45	44	47	49
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Avis / Note: Unités / Units : pourcent /percent (%) M = Manquant / Missing

- Résumé / Summary -

Sommaire quotidien de février 2005 **Aéroport International de Montréal/Dorval**		**Daily summary for February 2005** **Montreal/Dorval International Airport**	
Date		Date	
1 -	Continuation de l'épisode de smog débuté le 31 janvier 2005. Ennuagement en soirée.	1 -	Continuation of smog event beginning January 31th, 2005. Clouding over in the evening.
2 -	Smog. Doux.	2 -	Smog. Mild.
3 -	Smog. Doux.	3 -	Smog. Mild.
4 -	Smog. Ensoleillé. Très doux.	4 -	Smog. Sunny. Very mild.
5 -	Smog. Généralement ensoleillé. Très doux.	5 -	Smog. Generally sunny. Very mild.
6 -	Smog. Très doux.	6 -	Smog. Very mild.
7 -	Smog. Très doux.	7 -	Smog. Very mild.
8 -	Fin de l'épisode de smog. Pluie ou bruine intermittente débutant le matin et cessant en soirée. Très doux.	8 -	End of smog event. Intermittent rain or drizzle beginning in the morning and ending at the end of the day. Very mild.
9 -	Faible neige en matinée et en fin de journée. Très doux.	9 -	Light snow during the morning and at the end of the day. Very mild.
10 -	Neige cessant en soirée. Doux. Venteux causant de la poudrerie.	10 -	Snow ending in the evening. Mild. Windy causing blowing snow.
11 -	Ensoleillé. Doux.	11 -	Sunny. Mild.
12 -	Neige intermittente. Doux.	12 -	Intermittent snow. Mild.
13 -	Neige cessant durant la nuit. Ensoleillé.	13 -	Snow ending during the night. Sunny.
14 -	Faible neige débutant en après-midi, se transformant en grésil en soirée puis en pluie. Doux. Venteux.	14 -	Light snow beginning in the afternoon, changing into ice pellets in the evening then into rain. Mild. Windy.
15 -	Faible pluie se terminant le matin et recommençant en fin de journée. Très doux. Venteux.	15 -	Light rain ending early in the morning and then starting over at the end of the day. Very mild. Windy.
16 -	Pluie débutant tôt la nuit devenant mêlée au grésil et à la neige le matin, se changeant en neige en matinée et se terminant en soirée. Le tout accompagné de brouillard. Très doux.	16 -	Rain beginning early in the night, becoming mixed with ice pellets and snow early in the morning, changing into snow around mid-morning and ending in the evening. Foggy. Very mild.
17 -	Ensoleillé. Ennuagement graduel. Faible neige débutant en fin de journée. Doux.	17 -	Sunny. Increasing cloudiness. Light snow beginning at the end of the day. Mild.
18 -	Neige cessant en soirée.	18 -	Snow ending in the evening.
19 -	Averses de neige débutant en après-midi et se terminant en soirée.	19 -	Snow showers beginning in the afternoon and ending in the evening.
20 -	Ensoleillé. Froid.	20 -	Sunny. Cold.
21 -	Faible neige débutant en matinée. Venteux.	21 -	Light snow beginning in the morning. Windy.
22 -	Neige se terminant en fin de matinée. Quelques flocons en fin de journée.	22 -	Snow ending at the end of the morning. Few flurries at the end of the day.
23 -	Ensoleillé.	23 -	Sunny.
24 -	Ensoleillé. Froid.	24 -	Sunny. Cold.
25 -	Ensoleillé.	25 -	Sunny.
26 -	Généralement ensoleillé.	26 -	Mostly sunny.
27 -	Ensoleillé. Froid.	27 -	Sunny. Cold.
28 -	Couvert. Froid.	28 -	Overcast. Cold.