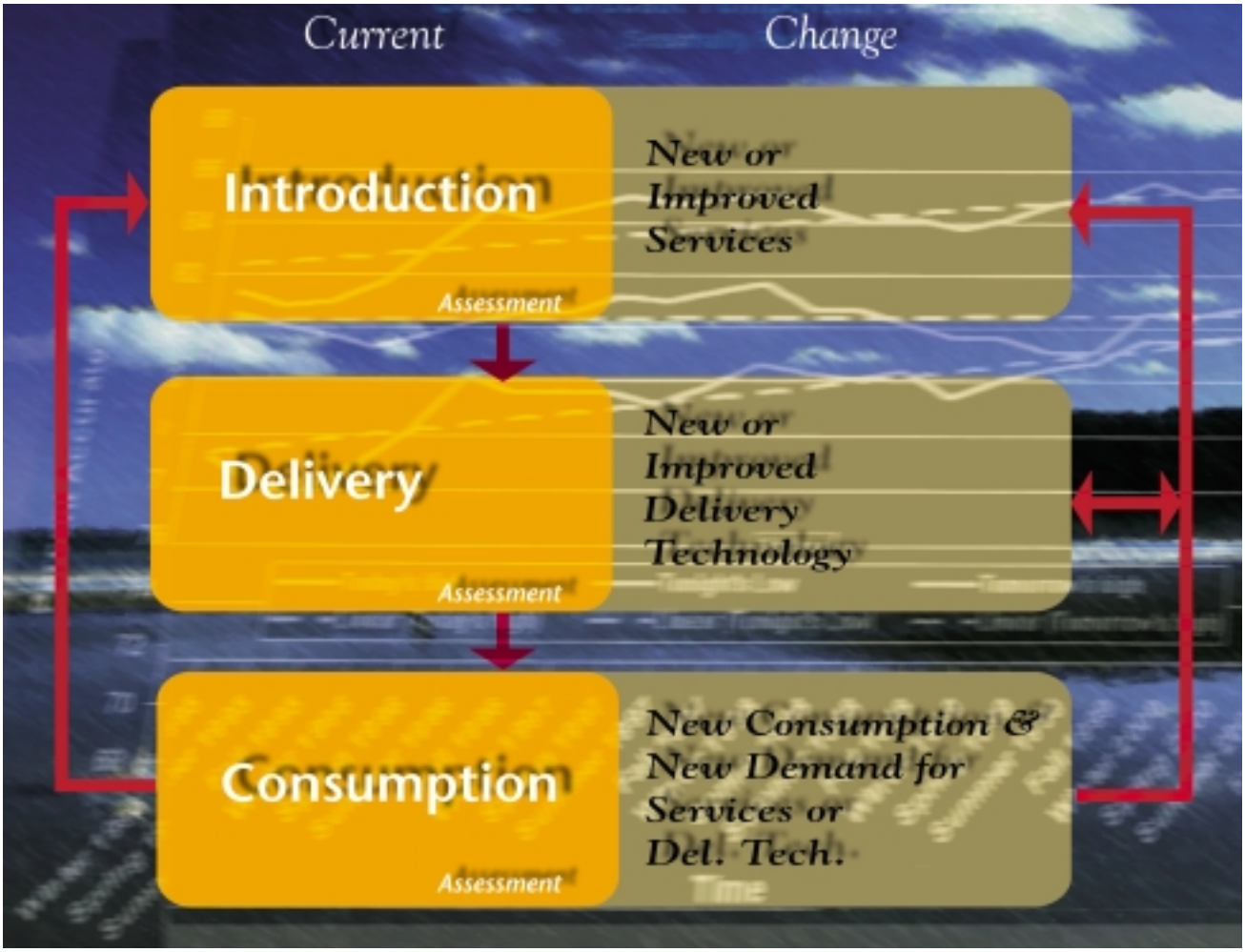
World Meteorological Organization

SUPPLEMENTARY GUIDELINES ON PERFORMANCE ASSESSMENT OF PUBLIC WEATHER SERVICES

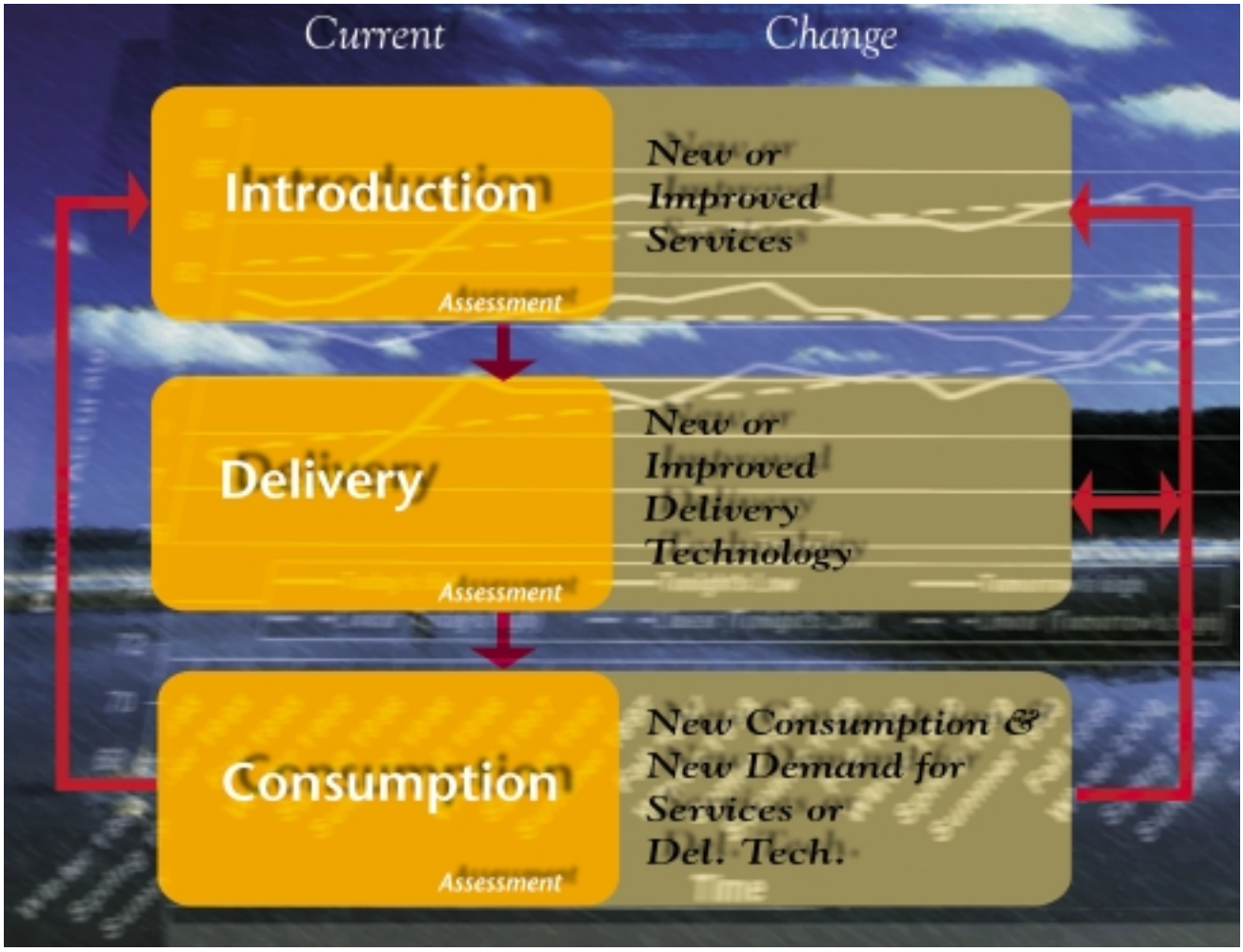
PWS-7 WMO/TD No. 1103



World Meteorological Organization

SUPPLEMENTARY GUIDELINES ON PERFORMANCE ASSESSMENT OF PUBLIC WEATHER SERVICES

PWS-7 WMO/TD No. 1103



Geneva, Switzerland
2002

Lead author and coordinator of text: Joseph Shaykewich

(Contributions by: C.C.Chan, Robert Landis,
Wolfgang Kusch, Yung-Fong Hwang, Samuel Shongwe)

Edited by: Haleh Kootval

Cover: Josiane Bagès

WMO/TD No. 1103

NOTE

The designations employed and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of any of the participating agencies concerning the legal status of any country, territory, city or area, or of its authorities, or concerning the delimitation of its frontiers or boundaries.

CONTENTS

Chapter 1

INTRODUCTION

The importance and necessity to carry out ongoing performance assessment of public weather services to ensure that they effectively and efficiently meet the needs of the public, have been well recognized. As part of the mandate of the Public Weather Services (PWS) Programme to assist Members with the development and improvement of their national public weather services programmes, the PWS Expert Team on Product Development and Verification and Service Evaluation developed a set of guidelines on technical and user-oriented verification mechanisms including measures of overall satisfaction with the service. Those guidelines which were published in 2000 as a WMO Technical Document (WMO/TD No.1023) brought into focus the subjective nature of user-based assessments as well as the key purposes and techniques to carry out such assessments.

The PWS Expert Team on Product Development and Service Assessment that was established by the Commission on Basic Systems (CBS) as the successor to the above expert team, was given the task to develop further guidance material, including relevant case studies and quantitative information, to assist NMSs in developing their skills in the planning and implementation of effective service assessment procedures to monitor user satisfaction and act on the findings.

The purpose of this Technical Document which is intended as a supplement to WMO/TD No. 1023, is to provide further elaboration of the concepts portrayed in WMO/TD No. 1023 and to re-enforce understanding through the provision of practical examples and models employed by various NMSs. Issues pertaining to some of the limitations of performance assessments are also discussed. Additionally, issues that require further investigation are highlighted. One broad area where further assessment focus is desirable is that of delivery of services as opposed to production of services. It is expected that future supplements will become available that will further explore avenues of assessment, provide best practice examples and elaborate or update those presented here.

Chapter 2

PERSPECTIVES ON THE PERFORMANCE ASSESSMENT PROCESS

2.1 AS A COMPONENT OF A SERVICE IMPROVEMENT STRATEGY

The public basically has certain requirements concerning the services that it receives from the NMS. These are efficient delivery systems, more convenient and seamless access to services and higher levels of quality and performance in service delivery. An NMS's service improvement strategy can be seen to consist of the adoption of a comprehensive continuous improvement planning and implementation approach to service improvement and client satisfaction; the establishment of documented baseline measures for client satisfaction for key services; preparation and implementation of annual service improvement plans based on client priorities for service improvement; establishment of a minimum improvement target over a fixed multiyear period for each key service; adoption and publication of core service standards for each service channel; incorporation of a results-based service improvement accountability for managers as part of existing performance management systems; and reporting within the existing annual planning and reporting processes on service standards and performance against them and on annual improvements in client satisfaction including progress against the multiyear target. Delivery on the elements of the service improvement strategy would serve to improve the accountability and transparency of the NMS to the public.

2.2 AS PART OF A QUALITY MANAGEMENT SYSTEM

The ultimate objective of a National Meteorological Service (NMS) is customers' satisfaction through having their needs met. First identifying the needs and expectations of the customers and converting these into requirements for the NMSs' products and services achieve that objective. The customer encompasses the range from the individual citizen to a nation's political leadership. These requirements all represent objectives that the NMS intends to achieve whether it is cost, delivery or the specification it will supply. Process management then encourages the NMS to achieve these output objectives by controlling the inputs to its process. This means controlling the material and information it uses, the training it gives its employees and the procedures it follows. These process inputs will in turn have their performance objectives.

ISO 9000:2000 is driven by measurable objectives and provides a useful hierarchy: Strategic; Functional; Operational; and Individual. The 'Strategic' objectives address issues such as position in the marketplace, organizational improvement goals and performance and delivery policies. The 'Functional' objectives reference the measurable objectives of each function and consistency with policies. The 'Operational' objectives relate to the requirements and objectives of the individual products and services. Finally, the 'Individual' objectives capture how personnel contribute to the achievement of objectives. The time bounds of these range from longer term (years) for strategic to the much shorter term (days, weeks) for individuals. The timings will vary depending on how tactically or strategically the organization behaves.

ISO 9000:2000 asks the questions: Is there an objective? Is it being measured? And finally and very importantly, is there action on the shortfall? So, which are the aspects of the quality system that should be measured and for which objectives should be set? The determination of the detailed customer requirements is paramount. That is, what is it exactly that the customer wants in terms of product, cost, delivery and supporting information. The measurement of the achievement of these key customer objectives must be done always, as they are the key drivers of the organization.

With these customer objectives clearly specified the NMS can then set objectives inside the organization aimed at supporting the 'customer satisfaction' objectives. Each step in delivering on the NMS's promise to the customer needs to be identified such as through process mapping. From the process map is built the quality plan that captures the primary objectives for each of the business processes (e.g.: forecast quality, delivery effectiveness, etc.). The primary objectives include those for outputs, inputs, resources etc. Of course everything cannot be measured on the process map, rather the risks associated with each process need to be assessed and the focus narrowed to those items where improvement can be gained from measuring. This risk assessment involves the evaluation of the strengths and weaknesses of the various features of each process. Every process is thereby evaluated and by applying the Pareto principle those processes requiring specific attention can be identified.

Next, for each of this reduced number of processes requiring more careful attention the need is to measure those parameters which are poor and have the greatest impact on the process; two or three parameters on each weak process, ideally the focus could be on one key parameter. A period of operation and observation may be required for this determination. For these selected parameters we need to set goals or objectives that are specific, challenging, measurable, agreed, realistic and time bound. Any corrective action requires the expenditure of scarce resources for which there are competing rivalries. The theory of governing dynamics would suggest judicious selection amongst these rivalries affording mutual gains through the employment of best response functions leading to an optimal total organizational benefit.

The above walk through illustrates some of the components of a process-based quality management system. Such a

system requires the exercise of management responsibility for the establishment of a quality policy and the setting of measurable quality objectives with a strong customer focus. The management of the human and infrastructure resources including the work environment is a critical aspect of a quality management system. Product design, realization and documentation are built around customer communication.

Finally, monitoring, measuring and analyzing customer satisfaction, internal processes and product quality allows for the control of non-conformities through corrective and preventative actions. A process-based quality management system supports the development of clearly defined standards of performance and responsibilities. With the strong client focus these standards are in a constant state of evolution as requirements evolve. The improved information to management results in higher overall efficiency and enhanced overall service levels. None of this comes without costs in terms of time and resources, especially up front, but these would normally be recouped later in the process. Some good examples of the implementation of the Quality Management System are emerging amongst NMS's. Two example references of this are found in CAeM-XII/Doc. 7(4) "The Implementation of the Quality Management System by the UK Met Office" and in CAeM-XII/Doc. 7(5) "Implementation of the quality assurance system at Météo-France".

These documents can be found on: http://www.wmo.ch/web/aom/amprog/documents/Caem-XII-2002/Docplan.htm.

There are many references on ISO 9000:2000 of which a good starting point is http://www.iso.ch/iso/en/iso9000-14000/index.html.

Chapter 3

CLIENTS OF ASSESSMENT AND REPORTING REQUIREMENTS

There is a broad dimension of needs that are satisfied through performance assessment activity. The managers of operational processes require the assessment information to manage the operations under their charge. At this level there is need to provide forecasters with information on where they add significant value, in order for them to concentrate their efforts on these cases or parameters. The managers of broad program areas require comparative information about the processes over which they have responsibility. Thus another objective is to provide statistical information on the performance of the public forecast program to regional and national managers who administrate the program. Funding agencies want performance information on the programs being funded. Finally, the customer, should it be the general public or a specific paying client, requires assurance that the product or service provided meets certain quality standards.

3.1 OPERATIONS

The 'Operational' objectives of an operational manager within an NMS relate to the requirements and objectives of the individual products and services: performance assessment of how well these are satisfied is necessary. The 'Individual' objectives of the staff of an NMS capture how personnel contribute to the achievement of objectives. By operations is meant those activities ranging from all forms of meteorological data acquisition to data and forecast production and to actual service delivery. These all represent elements of the process map with each of these process elements having objectives and features to be assessed. Certain key parameters of a process are assessed for their impact on that process or for their use as longer-term indicators of the quality dimensions of the process. The efficiency and effectiveness of the individual processes are monitored, and corrective or preventative actions are taken based on the information provided. It is at this level that primary customer requirements are reflected in the product or service.

3.2 MANAGEMENT

The 'Functional' objectives of an NMS reference the measurable objectives of each function and consistency with policies. The management of an NMS requires assessment information to monitor the health and effectiveness with which these functions are executed and their consistency with the strategic policy objectives. It is one thing to provide public weather services that meet user needs – and quite another to do it effectively and efficiently, from an overall point of view. The purpose here is not about what is delivered but rather how. The what is delivered is a policy decision undertaken at senior government levels although NMS management can recommend on this and influence the decision. At the management level it is the organization, management and planning of the overall public weather services system that delivers the services that is of concern. A performance assessment program can gather information that can be used to make decisions about the future delivery of services, staffing, training, research and development, and about the best mix of information from computer models and human value adding.

3.3 FUNDING AGENCY

The 'Strategic' objectives of an NMS address issues such as position in the marketplace for meteorological services, organizational improvement goals and performance and delivery policies. These need to fit within the policy mandate given to the NMS by the political decision-makers. Information on performance can be incredibly useful for gaining the support of stakeholders, including government ministers responsible for the NMS. The NMS will be in a much stronger position for sustaining and building funding if it can demonstrate such things as its level of performance, public satisfaction with its services, and the impacts of previous investment and research and development program.

3.4 PUBLIC

There are a wide variety of end-users of public weather services. These include individual members of the general public, emergency management agencies, and perhaps paying customers for specialized services. As stated in section 2.1, the needs and priorities that these end-users have for improving meteorological service delivery can be summarized as the requirement for easier, more convenient and seamless access to services and the requirement for higher levels of quality and performance in service delivery. The dimensions of public access alone represent a separate huge study area for performance assessment. The dimensions of quality and performance encompasse, amongst other things, what weather elements are most important, when and how forecasts should be delivered, in what format, and with what accuracy. Knowing what the needs are the focus can be narrowed to those items where improvement can be gained from measuring. Of course, the NMS's policy mandate as reflected in the 'Strategic' objectives (position in the marketplace for meteorological services, organizational improvement goals and performance and delivery policies) needs to be accommodated, as do the measurable objectives of each function, the 'Operational' objectives of the individual products and services and the 'Individual' objectives of the staff of an NMS.

An assessment program can assist in two ways – by finding out what the public perceptions are, and by gathering and publicizing facts about performance to improve the public perception and credibility of the services.

Chapter 4

THE ASSESSMENT PROCESS

The two major components of an assessment program are product verification and user-based assessment. The amount of effort spent on each will depend on the NMS, the nature of the services, and the user community.

The overall purpose of verification of forecasts is to ensure that products such as warnings and forecasts are accurate, skilful and reliable from a technical point of view. As far as possible, forecast verifications are produced in an objective fashion, free of human interpretation. The results tend to be numbers and statistics, which can be manipulated and interpreted using statistical theory. There is no guarantee that verification results will match people's perceptions of how good the forecasts are. On the other hand, user-based assessment should give a true reflection of the user perception of products and services provided by the NMS, as well as qualitative information on desired products and services. This type of assessment contains almost completely subjective information, subject to human perception and interpretation.

In carrying out an assessment program combining both components, there are some commonalities. Although verifications may typically provide objective numbers, they should still be based around numbers that are relevant to users. It should be possible to match user-based assessment results (e.g., of perceptions of forecast accuracy) with corresponding technical verification results, and seek common trends and patterns. Various types of scores and assessment methods have their particular uses.

4.1 ASSESSMENT AS A CONTINUOUS PROCESS

An NMS's domain of concern can be represented by the following simplistic Service Feedback Loop model (Figure 1) where 'production' encompasses all of the data acquisition, analysis and modelling, and forecast functions. Delivery encompasses all means by which the end-user receives the good or service, including co-deliverers. Consumption represents the use being made of the good or service in the particular manner in which it is delivered. An integrated assessment system would have assessment activities at all of these levels.

As indicated in Chapter 2 , a quality plan needs to be built that captures the primary objectives for each of the business processes. The risks associated with each process need to be assessed and the focus narrowed to those items where improvement can be gained from measuring those parameters, which are poor and have the greatest impact on the process. This assessment process needs to be continuous and in a constant state of evolution and modification reflecting current realities. The assessment process should also include assessment of changes to the product suite and/or changes in the manner in which products are produced and delivered. Either of these changes may result in new consumption patterns and the demand for further new services or delivery mechanisms.

4.2 USED-BASED ASSESSMENTS

The acceptance of the NMS's products by the public and other users depends on a number of factors. Scientific accuracy is just one of those factors. As part of this "requirements process", decisions on what constitutes success need to be made. There is a need for both verification and user-based information for decision-making purposes by individuals, whether office managers or the most senior executives of the NMS. The information is used for day-to-day program delivery management as well as for longer-term vision and strategic planning. While the information gathered may serve

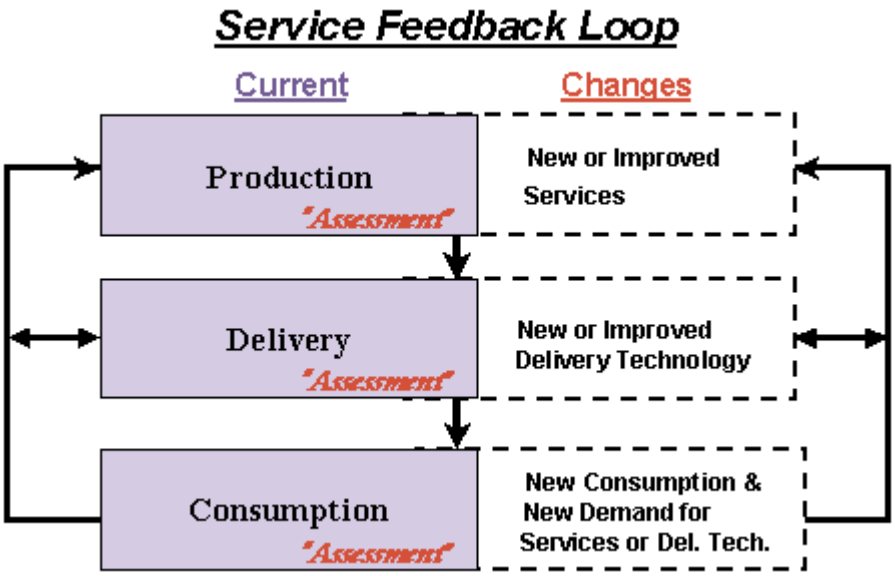


Figure 1 — Service Feedback Loop model

the objectives at a variety of levels within an organization, often the methodology chosen must be specific to the objectives at the organizational level.

User-based assessment is about measuring perceptions on a matrix of dimensions important to specific user communities and amongst a diversity of user communities. These perceptions include those about requirements in terms of accessibility, availability, accuracy, timeliness, utility, comprehension, language, sufficiency, and packaging. The user communities range from the individual citizen using the products to make personal decisions, to the media organizations essential for the communication of the product, to government agencies funding the production and delivery of those products. The health of the NMS depends on the requirements perceptions from the full spectrum of these users. User-based assessments are focused around the ability to obtain information on specific characteristics of interest through a variety of direct methods such as surveys, focus groups, public opinion monitoring, feedback and response mechanisms, consultations such as users meetings and workshops, and the collection of anecdotal information. On their own, each of these methods may produce information which is subjective and of questionable reliability. However, taken as a whole, a consistent picture often emerges which is credible. These methods are the only effective means by which information can be gathered on needs, expectations, satisfaction, etc. More recently, they have also been demonstrated as effective means for getting at the economic value of weather information and forecasts.

In developing the user-based assessment schedule the areas of research are selected on the basis of program need, risk management, and commitments in business plans, management frameworks, and performance frameworks. In such a multi-year strategy to user-based assessment it is important to cover both product lines and delivery mechanisms and to use consistent questions over the years for proper trend-line analysis. Performance measurement, after all, is about the change over time as opposed to the measurement of the state of affairs at a give point in time. Appendices A and B are examples of annual monitoring surveys administered by the Malaysian Meteorological Service and the Hong Kong Observatory respectively from which trends can be determined.

In most cases survey objectives call for the measurement of many characteristics. A comprehensive survey may include sets of questions on the general use of weather information, weather warnings, regular forecasts, air quality information, weather information delivery, demographics, etc. Within these sections of a multi-purpose survey further breakdowns can occur such as under the general topic of weather forecast or on a per season basis, one can investigate perceptions of what is considered accurate for temperature, wind direction/speed, onset of precipitation, probability of precipitation, sky cover conditions (sunny, cloudy, etc.).

These surveys are usually quite long and demand fairly large sample sizes to facilitate geo-politically-based inferences. To accommodate the measurement of several items within one survey plan, it is likely necessary to make compromises in many areas of the survey design. The survey design must be made to properly balance statistical efficiency, time, cost, and other operational constraints. As such, these baseline surveys tend to be rather costly; therefore they are usually undertaken once every four or five years. In order to make proper inferences on trends, consistency in the design and questions from one baseline survey to the next is necessary.

An example of such a baseline survey, the Canadian 2002 Decima Research Inc. Survey, is given in Appendix C. This survey is a follow-up to the 1997 baseline Canadian Goldfarb Survey (see WMO/TD 1023). In Appendix C the changes made to the previous survey are identified to illustrate not only the degree of consistency between the two surveys but also the natural evolution of the user-based information requirements of a healthy public weather services program.

4.3 SCIENTIFIC PROGRAM ASSESSMENT

The overall purpose of verification is to ensure that products such as warnings and forecasts are accurate, skilful and reliable from a technical point of view. The accuracy of a forecast is some measure of how close to the actual weather the forecast was. The skill of a forecast is taken against some benchmark forecast, usually by comparing the accuracy of the issued forecast with the accuracy of the benchmark. Reliability means the extent to which the forecast can be "trusted" on average. One measure of reliability would be the average bias in a maximum temperature forecast – the average of the forecast values minus the average of the observed values. These concepts are treated in depth in WMO/TD 1023. The decisions on what scores are to be calculated and the rigor built into the process of calculation (variety of scores, infrastructure, automation, etc.) are a function of performance information requirements of operations, management, funding agencies and the public. These requirements are elicited through the user-based assessment process.

4.4 ASSESSMENT OF END-USER REQUIREMENTS

The determination of the detailed customer requirements; what exactly the customer wants in terms of product, cost, delivery and supporting information, and the measurement of the achievement of these key customer objectives must always be undertaken as a first step, as they are the key drivers of the organization. First identifying the needs and expectations of the customers and then converting these into requirements for the NMS's products and services achieve the ultimate objective of customer satisfaction. These requirements all represent objectives that the NMS intends to achieve in terms of costs, delivery and the specification of the supplied products and services.

In order to make sure that requirements of the wide variety of end-users of public weather services are being met, first of all it is necessary to know what they are and a key to determine that is by asking the users. The definition of the needs in the particular case of weather forecasts can encompass what weather elements are most important, when and how forecasts should be delivered, in what format, and

with what accuracy. Knowing what the needs are, it is necessary to find out whether they are being met, and take actions to improve where possible. Part of the user requirement is how the product is delivered, and when. This may be as simple as checking and then changing the issue time of forecasts to make sure that they are available when they are most useful. It can also involve keeping score on how many forecasts are issued late, and changing management practices and schedules to ensure that forecasts are issued on time. Even if public weather services have been designed and delivered to meet user needs, there may be a perception problem over how good they are. Similar methods need to be used to check with the users on what capabilities they have for accessing and receiving products, and then to improve the delivery system to better meet those needs. In part, the survey documents included as Appendices A, B and C have as their purpose the determination of such requirements. Often, focus groups and other forms of interactions with clients assist in the process of fine-tuning the requirements definition.

4.5 ASSESSMENT FOR THE DEVELOPMENT OR MODIFICATION OF A PROGRAM

While the public forecast product suite may have the appearance of little or no change, the public weather services program of any NMS is, in fact, in a constant state of evolution. To the traditional elements of temperature, wind, clouds and weather many NMSs have, fairly recently, added other parameters such as probability of precipitation and, on a seasonal basis, the UV Index. In many NMSs thermal indices are currently reviewed and some programs modified as a result. For example, in Canada and the USA changes to the wind chill programs have been made and the forecasting and warning program for extreme high temperatures is currently being reviewed. Also, many NMSs are currently examining the possible incorporation of health-based air quality indices. Additionally, technological advances have presented new opportunities in the area of delivery of public weather services products to the public, thus creating new opportunities and challenges with respect to the format and presentation of such information.

Finally, science, including numerical modelling, has advanced permitting efficiencies in the production and automation of products themselves. As illustrated in Figure 1 with any such changes the implementation of an integrated user-based assessment and verification program is desirable for their successful implementation and effective on-going operation. Appendix H illustrates the detailed process undertaken for the renewal of the Wind Chill Program for North America.

4.6 ASSESSMENT OF THE VALUE OF WEATHER FORECAST SERVICES

Information on weather and climate conditions provided by NMSs is of significant social benefit to their respective countries. Although it is widely assumed that the benefits of an NMS far exceed the costs of the services provided, there is often little reliable economic data supporting this. While providing their current services and planning new services by implementing new technologies, NMSs are increasingly required to justify that their expenditures meet fundamental economic requirements using some benefit-cost framework. In order to determine the optimal provision of these services, NMSs require information on not only the value of their current services, but also how the change in the mix of services, or in the characteristics of those services, will change the marginal benefits of services to the marginal costs. However, since the provision of services is most often financed through general tax revenues with no fees charged for access to the forecasts, the value of services is not revealed in the marketplace.

It should be noted that the application of resources to improve forecasts as determined by some technical measure of forecast accuracy, only represents the potential for increased value. There is no direct relationship between technical measures of forecast quality and households' values for forecasts. To elicit reliable and economically valid household values for improved or current weather services, the processes of production (current and new forecast services), delivery (current distribution systems and new innovative delivery technologies) and consumption (current consumption and new consumption patterns demand for new services and product delivery technologies) must be considered including the feedback loop from "consumption" to "production". The value of weather information relates to how individuals or economic entities can or will react to information or changes in information available when they face risk and uncertainty of future weather outcomes.

Microeconomic theory indicates that private and public producers should produce goods and services that will satisfy a demand. Meeting the level of demand requires producers to use available input resources to produce the particular good of greatest value relative to their other uses. Inputs are scarce and have opportunity costs such that any resources used to produce a particular good, limit the next best use of those resources for producing other goods or services. In determining the optimal expenditure of input resources on a particular good or service it is useful first to determine whether the good is either a private good or public good.

A private good is one that has characteristics of being rival in consumption and excludable. Rivalry in consumption means that if a person consumes a unit of the good, then either the quantity or quality of the remaining good has diminished for anyone else to consume. Excludability in consumption means that if a person consumes a unit of the good, or has rights to consume it, then they can exclude other people from consuming it. The value of private good is revealed explicitly by the market price for it.

Public goods have the characteristics of being non-rival in consumption and non-excludable meaning that as someone consumes a public good, the quantity or quality of the good is unaffected, and the same quantity and quality remain for other consumers. An example of a public good is a radio broadcast. Any one person listening to the broadcast cannot diminish the quality of the signal for other people (non-rival in consumption) nor can the consumer exclude others from

listening to it elsewhere (non-excludable). The characteristics of non-rivalry and non-excludability on consumption mean that private markets will not form since they will be unable to capture profits from the benefits they produce. The economic valuation problem associated with a public good is that its consumers do not have the incentive to reveal their true preferences meaning that one must find another way of valuing it in order to determine its level of provision.

Most goods embody both characteristics of rivalry and excludability and thus are private as well as public. Such mixed goods, commanding mixed markets, may be non-rival, but exclusive, or non-exclusive, but rival. The public and private good characteristics cannot be separated without an increased cost, or decreased benefit to society. If provided by a private market, there will need to be subsidies and/or regulations to ensure that the optimal level of supply is provided. On the other hand, a public provider should charge user fees for the private benefits from the service in order to cover the costs of these additional services, and therefore provide the optimal level of the mixed good. The determination of the appropriate user fees requires the valuation the private benefits, or at least the ratio of private versus public benefits. Like pure public goods, mixed goods require non-market valuation techniques to value them.

Weather information services differ from many types of other public goods because different users benefit differently from specific dissemination packages employed. The nature of weather information itself is a public good that has both non-rival and non-excludable characteristics. However, depending upon the type of dissemination medium employed, the information can have both public and private characteristics in combination. Public good is exemplified by the provision of public safety information over the airwaves to mitigate the costs of natural disasters. Specific components of data, systematically and carefully organized, packaged and sold to private firms for distribution, via the market, to agricultural and other industries that operate in private markets are examples of private goods. To justify, in economic terms, the provision of the meteorological services, it is crucial to determine the aggregate benefits of these services as reflected in the true preferences by the users. Non-market valuation techniques are required to determine the benefits these services provide to society. It is difficult to determine the economic value of changes in the services provided as a result of an NMS's programs to improve weather forecasting and yet this is exactly what is required in a benefit-cost analysis.

It is possible to view non-market valuation of weather information services in a variety of perspectives. Two basic approaches that economists use are revealed preference methods and stated preference methods. Revealed preference methods use actual behaviour and market transactions to reveal implicitly values of a non-market good. Stated preference methods use surveys to sample the stated preference that can be directly or indirectly used to determine the willingness-to-pay for a good or service. An alternative categorization of these methodologies of valuation is Production-based and Demand-based. Production-based approaches indirectly impute a value as an input to a productive process based on what end-users of the final product are willing to pay for it. Production-based methods rely on the modelling of the processes in which the information is used as an input to the production of a consumer product. The final product is ultimately valued in the marketplace and the value of the weather information, as an input, is extrapolated from the final value. Thus the benefits of the information input as the contribution to the market value of the final product is indirectly inferred. Aggregation of such values covering all possible applications to achieve a net value for the information service is not possible as it is not feasible to model all those possible applications.

On the other hand, a Demand-based approach infers the value of the productive input directly according to the demand for that input as expressed as the primary users' willingness to pay for it. Demand methods model the relationship between willingness to pay for a service and the benefits generated by that service in aggregate over the range of all users. That is, users are provided with a means of revealing how much they would be willing to pay for the service if they had to do so. Revealed preference methods directly measure individual willingness to pay, and can easily differentiate between significant differences in willingness to pay among user groups, provided the sample of each is large enough. The individual willingness to pay for each user group can then be aggregated over the populations of users in each group that further can be summed to get the total value of the proposed change in the provision of the specific type of weather-information dissemination service throughout society.

Two main stated preference or demand based methods that are most often employed are Contingent Valuation and Conjoint Analysis. These methods use a hypothetical context in a survey format, but questions are designed as choices between, or rankings of preferences for, alternatives that include differences in goods and services as well as costs. The preferred alternatives reveal information on the perceived value for the goods or services. Such direct approaches use surveys to elicit individuals' willingness-to-pay for a non-market good or service, or willingness-to-accept compensation for losing the good or service. The contingent valuation method relies on survey techniques and hypothetical situations to directly elicit peoples' willingness to pay, or willingness to accept compensation, for hypothetical changes in the quality and/or quantity of a non-market good, contingent on the nature of the hypothetical market. Conjoint Analysis, specifically attribute-based choice analysis, elicits value estimates of each attribute of a good or service by asking respondents to choose a preferred alternative from a set of experimentally designed alternatives. While contingent valuation approaches tend to overlook the influence of substitutes on respondents' decisions, a choice-based approach provides these substitutes as alternatives where discrete choices must be made. The empirical application of conjoint analysis to public weather forecasts allows the researcher to derive the value that consumers derive from the various attributes of weather forecasts.

Appendix D provides a partial list of references on economic valuation of weather services that elaborate on the theoretical basis and actual application of non-market valuation techniques.

4.7 ASSESSMENT OF THE PERFORMANCE OF THE SCIENTIFIC PROGRAMS

Performance assessments of the routine public forecast elements are the main focus of this section. These assessments are treated from both the qualitative and quantitative perspectives. Qualitative assessments here are interpreted as user-based assessments that include the use of surveys, focus groups, and consultations, among others. Quantitative assessments mean scientific verification such as accuracy measures, lead-time measures, etc. Frequently, significant program components are the subject of assessments that have both qualitative and quantitative dimensions.

Many NMSs provide statistics on the performance of their numerical weather prediction models and routinely these statistics are assembled for international comparison purposes. Frequently these statistics are communicated to funding agencies to demonstrate positive results for the taxpayer's investment. This activity is necessary to ensure not only healthy competition amongst NMSs, but also more importantly to monitor progress in the science of numerical weather prediction. Relative comparison of NWP advances in accuracy to the accuracy of end-user products is important from the perspective of identifying where the emphasis in numerical weather prediction research should be placed relative to the accuracy needs of the end-user. Forecasts of precipitation timing and of amounts is a particular area that has been identified in several countries as a deficiency.

Many of the techniques described here can also be applied to seasonal and inter-annual forecasts. Longer-term forecasts such as decadal climate projections are made more difficult by the need for a valid scientific dataset for verification and adequate understanding for any qualitative assessment.

4.7.1 For External Reporting

For external reporting purposes sometimes the funding agency may insist on an assessment process that is independent of forecast operations. At times, formal audits of the assessment function are required or at least desirable. User-based assessments that involve surveys or focus groups are usually carried out by private sector firms contracted for such purposes. Usually, in government sectors, public opinion research results, while paid for by the individual NMSs, are in the public domain, that is, they are easily accessible by the public and interest groups. The need to maintain a reputation of integrity on the part of the private sector firms involved in this business is a force driving the credibility of the results of their endeavours. Scientific verification presents a challenge in transparency in this regard. One way of attempting to achieve a reputation of credibility is through the separation of the verification function from the forecast operations function. There can be ranges of variation in the degree of such separation.

Figure E1 'A System Independent from Forecast Operations' in Appendix E 'Canadian Automated Warning Performance Measurement System' is an example of a KPMG audited system that is completely independent from forecast operations. But even in such cases the drive for efficiencies in an increasingly scarce resource situation may mean sharing of centralized databases, decoding software, etc. with operational activities that may threaten the credibility that separation brings. Done right, and perhaps with audits of shared aspects, the credibility can be maintained.

4.7.2 In Support of Operations

The undertaking of performance assessments in support of operations is important for a number of reasons. As indicated in Chapter 5, the information is used internally for management, staff and program development purposes. User-based assessments provide valuable input on levels of satisfaction and utility of the variety of services an NMS provides and, importantly, provide information on where efforts to improve should be focused.

A performance assessment program can gather information that can be used to make strategic decisions about the future delivery of services, staffing, training, research and development, and about the best mix of information from computer models and human value adding. Many NMSs maintain verification regimes for their NWP activities and some of this information is exchanged internationally. Such information also provides guidance on where research and development efforts are to be focused. The most important verification effort, nevertheless, needs to be focused on the public forecast products that actually go out to clients who use them. Certainly, the delivery system involved has a significant impact on the effectiveness of the service provided and as such should be part of the assessment process. The actual public forecast production factors in critically here. For this a verification system that supports forecast production operations is needed. Figure F1 'A System Integrated with Forecast Operations' in Appendix F 'Canadian Automated Routine Public Forecast Performance Measurement System' is an example of a system designed for near real-time feedback to forecast operations.

4.8 ASSESSMENTS ASSOCIATED WITH HIGH IMPACT EVENTS

The NMS's weather warning program is designed to alert the public of weather events with potential high impact in terms of safety of life and security of property. Performance assessment of this program is critical to the credibility of an NMS. The assessment of a warning program has many dimensions. Firstly the assessment of the communication aspects of the warning program is critical. In addition, the effectiveness of the delivery system needs to be assessed through user-based assessment techniques and the operation of the systems requires monitoring and analysis. Equally important to the scientific assessment, is the message that is being communicated. Here, the appropriateness of the format and terminology used can be addressed through user-based techniques.

4.8.1 Assessment of Weather Warning Performance

In the case of severe weather warnings, scientific verification includes, amongst other parameters, lead-time, severity, aerial coverage, occurrence of severe weather elements and even the correct phase of precipitation. For precipitation events such as heavy snowfall agreeing on the definition of the time of start of an event that may start with light flurries adds to the complexity. The accuracy of the aerial coverage of a warning adds further significant complexity. An NMS's hourly observation network is woefully inadequate for assessing the accuracy of warnings of convective developments and localized events such as off-lake events. Radar systems can provide some surrogate information but these systems are expensive so networks are rarely adequate and the results subject to interpretation. Often, for verification purposes one must rely on subjective information from the public located at or near the event. In less densely populated areas often there is no one there to provide even such evidence but that does not mean that the event did not happen. Nevertheless, the collection of such data provided by the public is important for verification purposes and requires some rigor built into the process to enable coding for data analysis. Appendix M 'Severe Weather Event Data Definition' represents an attempt at such rigor.

4.8.2 Assessment of Disastrous Weather Events

In many countries major disastrous weather events are the subject of special studies. Frequently, independent experts are engaged for this purpose and sometimes, a national commission is employed for a full impact and public safety systems assessment. Post-event reviews or case studies help by bringing problems to the forefront and tend to be rather persuasive by providing extra motivation to make positive changes. Careful treatment of the case is essential to avoid biasing the interpretations. Most NMSs will undertake operational performance reviews following major meteorological events to assess the effectiveness of their systems. One such review was undertaken following the costly "Ice Storm" of January 1998 in Eastern Canada.

Reviews can result in complete end-to-end operational system audits of what worked effectively and what did not. It is common to analyze the accuracy and appropriateness of the meteorological products. The effectiveness of the information delivery system is a critical component to be analyzed, as is the effectiveness of the NMS's relationship with other agencies involved in disaster management. Surveys of the public and even the local media provide useful information. An assessment of the public "issue management" can lead to improved strategies for future similar situations. Documenting and learning from these situations are key steps towards improvements. A good example of a rigorous process is provided as Appendix L 'Ft. Smith and Van Buren, Arkansas, Tornado of April 21, 1996 Natural Disaster Survey Report –Executive Summary and Table of Contents-NWS-NOAA-USA'. Only the Executive Summary and the Table of Contents are provided but this is adequate to illustrate the rigorous method followed in such a programmed approach to assessment of major meteorological events.

The US National Weather Service (NWS) conducts service assessments to evaluate performance for catastrophic weather events. Service Assessments are performed either when there is a major economic impact on a large area or population; or when multiple fatalities or numerous serious injuries occur; or when an unusually high level of public or media interest is generated. In these cases reports are produced that explain what happened; what actions have been taken by the NWS before, during, and after the event; and that make recommendations for changes in NWS policy, procedures, products, and/or services to improve performance and emulate best practice. More information on Service Assessments in the USA is found in http://www.nws.noaa.gov/om/assessments/index.shtml.

4.9 ASSESSMENT OF AUTOMATED FORECAST PROCESSES

There is a trend in many NMSs to introduce increasing amounts of automation into the product generation activity. Indeed, some products such as the extended period outlook forecasts, are delivered to the end-user untouched by human forecasters. For such cases it is important to measure the scientific quality of those products and the degree to which they satisfy user needs. Where there is some human intervention in the production of the end-user product, such as at the weather element prediction level, it is important to monitor the value the human weather forecaster brings to the process. This is important not only from the perspective of location or period averages but also from the perspective of high impact weather events.

The UK Met Office "Added Value Chain", as contained in Appendix I, illustrates one example of how this can be undertaken. Here, the concept of "fix once, use many times" is employed, illustrating that human forecaster intervention early in the forecast "chain", is an efficient manner in which to employ scarce meteorologist resources.

Another example is the forecasts produced using the "Scribe" system in Canada. Appendix J 'Automated "Scribe" vs. Forecaster Accuracy' shows the comparative results of human forecasters versus automated forecast production. The top graphic illustrates the pure NWP output result. The bottom graphic illustrates the performance results of the human forecaster, which in more recent years, for about one half of the country's public forecast offices, includes the use of model scribe results as a starting point in the development of the public forecasts. It would appear that beyond the first day, on average, the forecaster does not add value. It would be easy to conclude that the forecaster should focus on the first day of the forecast where it would appear he has the greatest impact. The first caution is that these results are for forecasts of temperature only. It is not valid to extend these results to other forecast elements. Also, is the human forecaster better able to pick out those significant events of higher impact to the client, thereby contributing significant added value and is it justifiable to allow continued human intervention? To answer these questions, rigorous analysis is needed. This

highlights the need to interpret correctly the often limited verification results of certain forecasts.

4.10 APPROACH TO PRODUCT/SERVICE DEVELOPMENT AND ASSESSMENT BY GROUPINGS OF COUNTRIES

Some developing countries do not possess sufficient capacities in terms of technical, infrastructural, financial and related resources to develop and provide effective public weather products and services on their own. This situation therefore tends to render them largely low actors or none at all in product assessment activities and practices with the consequence that they hardly can achieve the added value that such an activity can bring to the overall operations of an NMS.

These challenges have developing NMSs to seriously seek alternatives that will enable them to emerge as meaningful players in fulfilling their mandates as providers of public weather services and all that it entails, including product assessment. A notable approach to doing this has been a move by NMSs of neighbouring countries to form regional groupings where more or less similar features (economic, geographic and climatic) exist. They do this to foster joint cooperation amongst Members in developing and issuing forecasts and other products from a regional setting, which eases the constraints imposed by the otherwise insufficient resources and abilities of individual Members. The participating Members then take ownership of the finished products as well as the responsibility of their dissemination to the local user communities as appropriate (with or without further enhancement). Scientific assessment can occur at either the level of the issuing country or at the level of the benefiting country or, perhaps more properly, at both levels. User-based assessment, nevertheless needs to be undertaken at a national versus regional level to ensure against biasing influence from neighbouring countries.

An example of a regional grouping of countries can be found in the Southern African Develop Community (SADC) region where some fourteen countries (Angola, Botswana, The DRC, Lesotho, Malawi, Mauritius, Mozambique, Namibia, The Seychelles, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe) of the region grouped together in what is called a Southern African Climate Outlook Forum (SARCOF). The forum was composed against the backdrop of the region's heavy reliance on agricultural production and hence the common requirement of an effective planning tool based on seasonal forecasts for purposes of decision making in the allocation of resources and scheduling of activities and practices within the supporting sectors. An assessment of the successes and needs for improvement of SARCOF can be found at the following Website: www.ogp.noaa.gov/enso/retro/sarcofchrt58.htm.

Chapter 5
REPORTING ON ASSESSMENTS

Both scientific verification and user-based assessment activities have a fairly broad spectrum of audiences. User-based assessment information is used at all levels of operations and management including central funding agencies. This information is used internally for management, staff and program development purposes and externally for communication on the NMS's activities. The scientific verification information is used to satisfy similar needs. In both cases care must be taken in communicating this information both internally and externally. Scientific verification presents a particular challenge when communicating outside the traditional scientific community.

The information on overall performance of the public weather services must be communicated to the public via the media when opportunities present themselves or routinely through the NMS's Web site to build public support and credibility. Managers need information to guide them in decision-making. Forecasters need information by way of feedback on their performance, particularly in relation to systematic errors that may need to be corrected. Researchers need information on performance of the system, and on likely new products so they can plan and prioritize research and development. All staff need information on the technical accuracy of the services delivered, and on public expectations, perceptions and needs. Information on performance must be communicated to the government on behalf of the taxpayers, the principal source of funds for the NMS, to demonstrate performance and the beneficial impacts of previous investment in the NMS, and to support future plans for the development of the NMS.

Since user-based assessment is quite costly, it is important to maintain both the reports and raw data in hard and electronic media , with backup copies, for future use and possible reanalysis. The material can be supplied to a variety of users for purposes ranging from management for decision making purposes, staff for internal awareness, funding authorities for resource justification, the public or stakeholders for end-user awareness and education, regulatory bodies for the attainment of approvals, and central agencies to satisfy reporting requirements. It is important that the data is properly indexed and easily retrievable.

The communication of the results to staff and management will assist in the evolution to a more client-centred organization that can lead to improved products, production efficiency and delivery or even end-user awareness and education thrusts. Communication upwards through higher levels of management will assist in the longer term strategic planning and management for the NMS.

Communication to central agencies may be a defined requirement but can also be used as a justification for resources (current and additional). Communication of the results externally may have the effect of modifying certain practices, such as those related to safety, or may encourage or accelerate the development of new services or products within the private sector. Communication to the general public can have the effect of increasing awareness and credibility of the NMS and its offerings. An example of performance reported via the Internet can be seen at http://www.crh.noaa.gov/arx/svr_verify.html.

The information needs to be presented in a brief and easily understood fashion. The example shown in Appendix G 'Performance at Varying Levels of Accuracy' taken from page 5 of the Deutscher Wetterdienst Verifikationsbericht report of February 2001 illustrates one way of presenting verification of deterministic forecasts of values of continuous variables. Through knowing his individual accuracy requirements for a specific forecast element, the end-user can obtain information on the frequency within which that accuracy is achieved. This type of accuracy presentation can be used for aerial or fixed-point forecasts over given periods or even for periods when specific meteorological criteria are met. Additionally, through the use of multiple curves the variation in performance can be demonstrated by location, season and years.

Performance reports often make their way into the annual reports of individual NMSs. Some of these reports, in whole or part, appear on the Web sites of NMSs. An example of this, from the Annual Report of the New Zealand Meteorological Service, is shown as Appendix K.

It is common to try to represent performance information as a trend over time. Over meaningful time scales this is usually valid, especially for certain meteorological elements. It needs to be recognized that user-based assessment information is second order information whose shortcomings need to be understood for its appropriate application. Chapter 5 of WMO/TD No. 1023 should be consulted for further details. The trend lines shown in Appendix J illustrate the improvement of temperature forecasts over time from automated processes as well as by the human forecaster.

Finally, scientific verification information must be shown as interpreted in an appropriate context. For example, low seasonal scores for the prediction of severe weather events may be more a function of the abnormality or complexity of the meteorological conditions of the season than the professional skills of the operational staff.

REFERENCES

Gordon, N.D., and Shaykewich, J.E. 2000 *Guidelines on Performance Assessment of Public Weather Services*. WMO/TD 1023.

Murphy, A.H., 1997. Forecast verification. In *Economic Value of Weather and Forecasts*, ed. R.W. Katz and A.H. Murphy, 19-74. Cambridge: Cambridge University Press.

UK Met Office. 2002. CAeM-XII/Doc. 7(4) "*The Implementation of the Quality Management System by the UK Met Office*"

Météo-France. 2002. CAeM-XII/Doc. 7(5) "*Implementation of the quality assurance system at Météo-France*".

NWS-NOAA, 1996. Natural Disaster Survey Report *"Ft. Smith and Van Buren, Arkasas, Tornado of April 21, 1996"*

Deutscher Wetterdienst. 2001. "*Verifikationsbericht zur güte lokaler Wettervorhersagen Nr. 23. Februar 2001"*

Treasury Board Secretariat, Government of Canada. 2000. *"A Policy Framenwork for Service Improvement*"

APPENDIX A
WEATHER FORECAST AND YOU — MALAYSIA SURVEY

GENERAL PARTICULARS OF RESPONDENT

AGE:
☐ 20 years & below ☐ 21 – 35 years ☐ 36 – 55 years ☐ Above 56 years

OCCUPATION: ..... RESIDENTIAL AREA: .....

NEWSPAPER READ:
☐ New Straits Times ☐ The Star ☐ Nanyang Siang Pau ☐ Berita Harian

☐ Utusan Malaysia ☐ Sin Chew Jit Poh ☐ Others (Please Specify) .....

LISTEN/READ/WATCH DAILY WEATHER FORECAST:
☐ Yes ☐ No

If YES, from which source:
☐ TV ☐ Radio ☐ Newspaper

☐ Others (Please Specify): .....

A. *Please use the following scale to answer the following questions.*

1 Very unsatisfactory	2 Not Satisfactory	3 Average	4 Good	5 Very good

1. What is your opinion on the accuracy of the forecast? ☐

2. What do you think of the presentation format? ☐

3. Timeliness of the forecast? ☐

B. *Please answer the following questions:*
4. Is the weather forecast useful for the planning of your activities?
☐ Yes ☐ No

5. How much do you think the weather forecast is worth?
☐ 0 cents ☐ < RM1/= ☐ RM 1/= - RM3/= ☐ RM3/= - RM5/= ☐ > RM5/=

6. Have you ever called the number 1052 or any of the Forecast Offices to enquire about the weather forecast?
☐ Yes ☐ No

If Yes, how many times?
.....

If No, why?
.....
.....

7. Comments:
.....
.....
.....
.....
.....

APPENDIX B
HONG KONG OBSERVATORY SURVEY

administered during the months of April and October every year

MAIN QUESTIONNAIRE

Q1 Do you usually read, watch or listen to weather reports?

1. Yes — Go to Q2
2. No — End of questionnaire

Q2 From where do you usually obtain weather information of Hong Kong? Do you obtain from radio, television, newspaper, weather hotline, internet, pagers / mobile phones, or other sources? Any other? (up to 3 sources)

(For "weather hotline", probe : Is it Hong Kong Observatory's Dial-a-Weather hotlines 1878-200, 1878-202 and 1878-066, or Hong Kong Observatory's Information Enquiry System 2926-1133 or Hong Kong Telecom's 18-501 and 18-503, 18-508?)

(For "internet", probe : Is it Hong Kong Observatory's Homepage or other homepages?)

1. Radio
2. Television
3. Newspaper
4. Hong Kong Observatory's Dial-a-Weather hotlines (1878-200 / 202 / 066)
5. Information Enquiry System (2926-1133)
6. Hong Kong Telecom's 18 501 / 3 / 8
7. Observatory's Home Page
8. Other weather homepages
9. Pagers / Mobile Phones
10. Other sources (please specify)

Q3a Do you consider the weather forecasts of the Hong Kong Observatory over the past several months accurate or inaccurate? (Probe the degree)

1. Very accurate
2. Somewhat accurate
3. Average
4. Somewhat inaccurate
5. Very inaccurate
6. Don't know / no comment

Q3b What percentage of weather forecasts of the Hong Kong Observatory over the past several months do you consider accurate ?

1. _____ per cent
2. Don't know / no comment

Q4 Do you consider the following aspects of weather forecasts of the Hong Kong Observatory over the past several months accurate or inaccurate?

	Inaccurate	Accurate	Don't know/ No comment
Temperature			
Fine / Cloudy			
Rain storm forecasts / warning			
Typhoon prediction / warning			

Q5 How do you compare weather forecasts nowadays with those from the past 3 to 4 years ago? Is it more accurate, less accurate or about the same?

1. More accurate
2. About the same
3. Less accurate
4. Don't know / no comment

Q6 How satisfied are you with the services provided by the Hong Kong Observatory? If you rate on a scale of 0 to 10, with "5" being the passing mark and "10" being "excellent service", how many marks will you give?

End of Questionnaire

APPENDIX C
ENVIRONMENT CANADA (MSC) NATIONAL METEOROLOGICAL PRODUCTS AND SERVICES SURVEY - 2002

(Decima Research Inc., March 14, 2002)

INTRODUCTION

Good afternoon/evening. My name is _____ and I am calling from Decima Research, a public opinion research company. Today we are conducting a survey on weather services currently provided to Canadians. Please be assured that we are not selling anything. We are simply interested in your attitudes and opinions.

We choose telephone numbers at random and then select one person from each household at random to be interviewed. To do this, we would like to speak to the person in your household, 18 years or older, who has had the most recent birthday.

[IF ASKED: The survey will take about 20 minutes to complete]
[IF ASKED: I can tell you at the end who sponsored this survey]

IF PERSON SELECTED IS NOT AVAILABLE, ARRANGE FOR CALL-BACK

SECTION ONE: USE OF WEATHER INFORMATION

1. To begin, I would like to ask you about the types of news that you hear or look at. During a typical day, how likely are you to look at or hear news on each of the following topics? Are you very likely, somewhat likely, not very likely, or not at all likely to get news on [READ AND ROTATE]

	Very Likely	Somewhat Likely	Not Very Likely	Not At All Likely	Depends	Don't know/ no answer
Local events and politics	☐	☐	☐	☐	☐	☐
Entertainment	☐	☐	☐	☐	☐	☐
Weather	☐	☐	☐	☐	☐	☐
Traffic	☐	☐	☐	☐	☐	☐
Sports	☐	☐	☐	☐	☐	☐

2. We'd like to focus more on weather information for the remainder of the interview. How important is it for you to have information about weather? Is it:

☐ Critically important
☐ Definitely important
☐ Somewhat important
☐ Not very important
☐ Not at all important
☐ Don't know/No answer

3. I would like you to think about the four seasons, in terms of the importance that weather information holds for you. Would you say that weather information during … is critically important, definitely important, somewhat important, not very important, or not at all important? [READ SEASONS IN SEQUENCE, WITH RANDOM START]

	Critically important	Definitely important	Somewhat important	Not very important	Not at all important	Don't know/ no answer
a. Spring	☐	☐	☐	☐	☐	☐
b. Summer	☐	☐	☐	☐	☐	☐
c. Fall	☐	☐	☐	☐	☐	☐
d. Winter	☐	☐	☐	☐	☐	☐

4. What specific types of weather information do you generally need, that is information you would use in any season to make decisions or plans? [MODIFIED] [DO NOT READ - CODE FIRST AND OTHER MENTIONS SEPARATELY – CODE UP TO SIX] PROBE: Anything else?

- ☐ Temperature - General (PROBE FOR SPECIFICS)
- ☐ Temperature - Accurate forecast/information
- ☐ Temperature - Maximum high/low
- ☐ Wind chill
- ☐ Humidity/humidex
- ☐ Road/Highway conditions
- ☐ Precipitation - General (PROBE FOR SPECIFICS)
- ☐ Precipitation – (Type: rain/snow)
- ☐ Precipitation – (Type: freezing rain, ice pellets, sleet)
- ☐ Precipitation - Amount (heavy/light)
- ☐ Precipitation - When it will start/end
- ☐ Precipitation - probability of occurrence
- ☐ Expected weather changes
- ☐ Storm warning/probability/expectations
- ☐ Wind direction
- ☐ Wind speed (gusty)
- ☐ Visibility/Reduced visibility
- ☐ Amount of sun
- ☐ UV index
- ☐ Air quality
- ☐ Accuracy
- ☐ More frequent reports/faster updates
- ☐ More precise/local weather information
- ☐ Long term forecasts
- ☐ More detailed information
- ☐ Weather conditions in other regions
- ☐ Historical information (record high/low temperatures/snowfall)
- ☐ Tide/marine information
- ☐ Other (SPECIFY _____)
- ☐ None
- ☐ Don't know /No answer

5. Compared with two years ago, would you say that today you are using weather forecasts more often, about the same, or less often than you were two years ago?

- ☐ More often
- ☐ About the same
- ☐ Less often
- ☐ Don't Know/No answer

6. On a typical day, how many times would you say that you specifically make a point of looking at or listening to weather forecasts? Would it be: [READ]

- ☐ More than four times a day
- ☐ Three times a day
- ☐ Two times a day
- ☐ Once a day
- ☐ Less than once a day
- ☐ Depends
- ☐ Don't know/No answer

7. And on a typical day, when do you make a point of trying to look at listen to weather forecasts? [DO NOT READ - CODE FIRST AND OTHER MENTIONS SEPARATELY - CODE UP TO SIX]

- ☐ Morning
- ☐ Afternoon
- ☐ Evening
- ☐ Other (SPECIFY _____)
- ☐ Don't know/No answer

8. Which one of the following forecasts is most important to you? Is it: [MODIFIED] [READ - CODE ONE ONLY]

- ☐ The forecast for that particular day
- ☐ The forecast two days in advance
- ☐ The forecast for three or more days in advance
- ☐ All equally important
- ☐ Depends on the weather
- ☐ Depends on the season
- ☐ Other (SPECIFY _____)
- ☐ Don't know/No answer

9. I am also interested in where you get your weather information from. From which source are you most likely to get your daily weather information? Are there any other sources do you rely on for weather information? [DO NOT READ - CODE FIRST AND OTHER MENTIONS SEPARATELY - CODE UP TO SIX]

- ☐ Television - general mention (PROBE FOR SPECIFICS)
- ☐ Television - Weather network/Weather channel/Météomédia
- ☐ Television – Local TV station forecasts

- ☐ Television – bar running across bottom of screen/crawler
- ☐ Television – Local Environment Canada cable channel
- ☐ Radio – Local stations
- ☐ Newspaper
- ☐ Internet/web sites – non-specific
- ☐ Environment Canada web site/The Green Lane/Weather Office
- ☐ Weather Network web site
- ☐ Personal digital assistant (Palmpilot/Blackberry)
- ☐ E-mail
- ☐ WeatherRadio Canada
- ☐ WeatherCopy Canada
- ☐ Environment Canada (PROBE FOR SPECIFICS)
- ☐ Telephone - general mention (PROBE FOR SPECIFICS)
- ☐ Telephone - 1-800 number
- ☐ Telephone - 1-900 number
- ☐ Environment Canada - recorded tape
- ☐ Family member/friend/Word of mouth
- ☐ None
- ☐ Other (SPECIFY _____)
- ☐ Don't know/No answer

10. How often does the weather information you get on a typical day provide you with enough information to make whatever decisions or plans you need to make? Is it: [READ]

- ☐ Always SKIP TO Q.12
- ☐ Usually SKIP TO Q.12
- ☐ Sometimes
- ☐ Rarely
- ☐ Never
- ☐ Don't know/No answer SKIP TO Q.12

11. (IF SOMETIMES/RARELY/NEVER) What other weather information would you need? That is, information you are not currently getting most or all of the time? [MODIFIED] [DO NOT READ – CODE FIRST AND OTHER MENTIONS SEPARATELY – CODE UP TO SIX]

- ☐ Temperature – non-specific
- ☐ Temperature – high/low
- ☐ Amount of snow/rain
- ☐ Probability of precipitation
- ☐ Wind speed
- ☐ Type of precipitation
- ☐ When precipitation will start
- ☐ Whether precipitation will be light/heavy
- ☐ Storm expectation
- ☐ Expected weather changes
- ☐ Road/highway conditions
- ☐ Accuracy
- ☐ More frequent reports/faster updates
- ☐ More precise local weather conditions
- ☐ More detailed information
- ☐ Long term forecasts
- ☐ Amount of sun
- ☐ Visibility/reduced visibility
- ☐ Significance of wind chill
- ☐ Direction of wind
- ☐ Humidity/Humidex level
- ☐ Marine/tidal information
- ☐ Other (SPECIFY _____)
- ☐ None
- ☐ Don't know/No answer

12. Overall, how satisfied are you with your current ability to get weather forecast information when you need it? Are you:

- ☐ Very satisfied (5)
- ☐ Satisfied
- ☐ Neutral
- ☐ Dissatisfied
- ☐ Very dissatisfied (1)
- ☐ Don't know/No answer

12.1 Most people get their weather information from TV and radio. Who, specifically, do you think is the provider of this weather information to these media outlets? [DO NOT READ - CODE FIRST AND OTHER MENTIONS SEPARATELY - CODE UP TO SIX]

- ☐ Environment Canada
- ☐ Meteorological Service of Canada
- ☐ Canadian Weather Service
- ☐ Department of the Environment
- ☐ Federal Government/Canadian government
- ☐ The Weather Network
- ☐ The media (TV, Radio, Newspapers)
- ☐ Private meteorology/weather companies
- ☐ Accuweather
- ☐ Meteorologists/forecasters
- ☐ Airports
- ☐ Other (SPECIFY _____)
- ☐ Don't know/No answer

Now changing topics a bit . . .

13. Which of the following best describes your current employment status? [MODIFIED] [READ IF NECESSARY - CODE ONE ONLY]

- ☐ Employed - full time
- ☐ Employed - part time
- ☐ Self-employed
- ☐ Currently looking for work SKIP TO Q.18
- ☐ Homemaker SKIP TO Q.18
- ☐ Retired SKIP TO Q.18
- ☐ Student SKIP TO Q.18
- ☐ Other (SPECIFY _____) SKIP TO Q.18
- ☐ No answer/Refuse SKIP TO Q.18

14. (IF EMPLOYED/SELF EMPLOYED) Which of the following best describes where you work? Do you: [NEW] [READ - CODE ONE ONLY]

- ☐ Work mostly indoors
- ☐ Work mostly outdoors, or
- ☐ Work both indoors and outdoors
- ☐ Other (SPECIFY _____)
- ☐ Don't know/No answer

15. How often does your work or job require you to make decisions based on the weather? Is it:

- ☐ Always
- ☐ Usually
- ☐ Sometimes
- ☐ Rarely
- ☐ Never SKIP TO Q.18
- ☐ Depends
- ☐ Don't know/No answer SKIP TO Q.18

16. And what type of weather forecast information do you need to make work-related decisions? [DO NOT READ - CODE FIRST AND OTHER MENTIONS SEPARATELY – CODE UP TO SIX] PROBE: Anything else?

- ☐ Temperature - General (PROBE FOR SPECIFICS)
- ☐ Temperature - Accurate forecast/information
- ☐ Temperature - Maximum high/low
- ☐ Wind chill
- ☐ Humidity
- ☐ Road/Highway conditions
- ☐ Precipitation - General (PROBE FOR SPECIFICS)
- ☐ Precipitation – Type: rain/snow)
- ☐ Precipitation – (Type: freezing rain, ice pellets, sleet)
- ☐ Precipitation - Amount (heavy/light)
- ☐ Precipitation - When it will start/end
- ☐ Precipitation - probability of occurrence
- ☐ Expected weather changes
- ☐ Storm warning/probability/expectations
- ☐ Wind direction
- ☐ Wind speed (gusty)
- ☐ Visibility/Reduced visibility
- ☐ Amount of sun
- ☐ UV index
- ☐ Air quality
- ☐ Accuracy
- ☐ More frequent reports/faster updates
- ☐ More precise/local weather information
- ☐ Long term forecasts
- ☐ More detailed information
- ☐ Weather conditions in other regions
- ☐ Historical information (record high/low temperatures/snowfall)
- ☐ Marine/tidal information
- ☐ Other (SPECIFY _____)
- ☐ None
- ☐ Don't know /No answer

17. What is your main source of weather information for work-related decisions? And what other sources do you rely on for such decisions? [DO NOT READ - CODE FIRST AND OTHER MENTIONS SEPARATELY - CODE UP TO SIX]

- ☐ Television - general mention (PROBE FOR SPECIFICS)
- ☐ Television - Weather network/Weather channel/Météomédia
- ☐ Television – Local TV station forecasts
- ☐ Television – bar running across bottom of screen/crawler
- ☐ Television – Local Environment Canada cable channel
- ☐ Radio – Local stations
- ☐ Newspaper
- ☐ Internet/web sites – non-specific
- ☐ Environment Canada web site/The Green Lane/Weather Office
- ☐ Weather Network web site
- ☐ Personal digital assistant (Palmpilot/Blackberry)
- ☐ E-mail
- ☐ WeatherRadio Canada
- ☐ WeatherCopy Canada
- ☐ Environment Canada (PROBE FOR SPECIFICS)
- ☐ Telephone - general mention (PROBE FOR SPECIFICS)
- ☐ Telephone - 1-800 number
- ☐ Telephone - 1-900 number
- ☐ Environment Canada - recorded tape
- ☐ Family member/friend/Word of mouth
- ☐ None
- ☐ Other (SPECIFY _____)
- ☐ Don't know/No answer

SECTION TWO: WEATHER FORECASTING ACCURACY/INFORMATION

Now moving to the topic of accuracy *in weather forecasts . . .*

18. Overall, how satisfied are you with the accuracy of the weather information and forecasts you currently receive? (IF ASKED: Accuracy means that the weather which was predicted actually happens) Would you say you are:

- ☐ Very satisfied (5)
- ☐ Satisfied
- ☐ Neutral
- ☐ Dissatisfied
- ☐ Very dissatisfied (1)
- ☐ Don't know/No answer

19. Compared with two years ago, would you say the accuracy of weather forecasts today is: [NEW] [READ]

- ☐ Much better
- ☐ Somewhat better
- ☐ About the same
- ☐ Somewhat worse
- ☐ Much worse
- ☐ Don't know/No answer

20. REMOVED

FOR Q.21 -33) - SPLIT RANDOMLY INTO THREE GROUPS: SUMMER—FALL/SPRING—WINTER

SECTION TWO A: SUMMER

I would now like to know your opinions about the accuracy of various types of weather forecasts. Consider a summer forecast that you might hear in July for your area.

S21a. Let's say that this forecast states the anticipated high for the day would be 20 degrees Celsius. Suppose the actual high is not 20, but some temperature cooler than 20 degrees. At what temperature below 20 would you consider the forecast to be inaccurate? (ENSURE RESPONDENT GIVES ANSWER AS A TEMPERATURE, NOT AS A RANGE)

_____ temperature (in degrees Celsius) ☐ Don't know/No answer

S21b. Now suppose the actual high is not 20, but is some temperature warmer than 20. At what temperature above 20 would you consider the forecast inaccurate? (ENSURE RESPONDENT GIVES ANSWER AS A TEMPERATURE, NOT AS A RANGE)

_____ temperature (in degrees Celsius) ☐ Don't know/No answer

S22. How much importance do you place on the accuracy of summer temperature forecasts? Would you say it is: [NEW]

☐ Very important (5)
☐ Important
☐ Neutral
☐ Unimportant
☐ Very unimportant (1)
☐ Don't know/No answer

S23. And how satisfied are you overall with the accuracy of summer temperature forecasts provided? Are you: [NEW]

☐ Very satisfied (5)
☐ Satisfied
☐ Neutral
☐ Dissatisfied
☐ Very dissatisfied (1)
☐ Don't know/No answer

S24. Turning now to the accuracy of precipitation forecasts, say that "heavy rain" over the next 24 hours is forecast. Would you consider this forecast to be accurate or inaccurate if actually: [MODIFIED] READ AND ROTATE

		Accurate	Not Accurate	Don't know/ no answer
a.	The ground was slightly wet	☐	☐	☐
b.	There are some puddles	☐	☐	☐
c.	A lot of water has accumulated	☐	☐	☐
d.	Basements have been flooded	☐	☐	☐

S25. How much importance do you place on the accuracy of summer precipitation forecasts? Would you say it is: [NEW]

☐ Very important (5)
☐ Important
☐ Neutral
☐ Unimportant
☐ Very unimportant (1)
☐ Don't know/No answer

S26. Which of the following parts of a summer precipitation forecast is most important to you? Is it: [MODIFIED] READ AND ROTATE - CODE ONE ONLY

☐ The type of precipitation
☐ When it happen
☐ How much precipitation will fall
☐ The probability or chance that it will occur
☐ All equally important
☐ None of the above
☐ Other (SPECIFY _____)
☐ Don't know/No answer

S27. And how satisfied are you overall with the accuracy of summer precipitation forecasts provided? Are you:

- ☐ Very satisfied (5)
- ☐ Satisfied
- ☐ Neutral
- ☐ Dissatisfied
- ☐ Very dissatisfied (1)
- ☐ Don't know/No answer

S28. Thinking now about wind during summer, which of the following is most important to you in terms of a [summer/fall/winter] forecast? READ AND ROTATE - CODE ONE ONLY

- ☐ Wind speed
- ☐ Wind direction
- ☐ Wind chill [WINTER AND FALL/SPRING ONLY]
- ☐ All equally important SKIP TO Q.30
- ☐ None of the above SKIP TO Q.30
- ☐ Other (SPECIFY _____) SKIP TO Q.30
- ☐ Don't know/No answer SKIP TO Q.30

S29. You said that [Q.42 RESPONSE] is the most important aspect of wind for you. How satisfied are you with the accuracy of the weather information provided on [Q.42 RESPONSE]? Are you:

- ☐ Very satisfied (5)
- ☐ Satisfied
- ☐ Neutral
- ☐ Dissatisfied
- ☐ Very dissatisfied (1)
- ☐ Don't know/No answer

S30. Thinking now about sun and cloud during the summer, how satisfied are you with the accuracy of the weather forecasts provided for sun and cloud conditions? Are you:

- ☐ Very satisfied (5)
- ☐ Satisfied
- ☐ Neutral
- ☐ Dissatisfied
- ☐ Very dissatisfied (1)
- ☐ Don't know/No answer

S31. Now thinking about reduced visibility due to fog or heavy rain, how satisfied are you with the accuracy of the weather information provided on visibility conditions? Are you:

- ☐ Very satisfied (5)
- ☐ Satisfied
- ☐ Neutral
- ☐ Dissatisfied
- ☐ Very dissatisfied (1)
- ☐ Don't know/No answer

And now turning to another type of weather information . . .

S32a. Are you familiar with the " UV index"? [NEW]

- ☐ Yes
- ☐ No SKIP TO Q.34
- ☐ Don't know/No answer SKIP TO Q.34

S32b. How useful do you find the UV index as part of summer weather forecasts? Is it: [NEW]

- ☐ Very useful SKIP TO Q.33
- ☐ Somewhat useful SKIP TO Q.33
- ☐ Not very useful
- ☐ Not at all useful
- ☐ Don't know/No answer SKIP TO Q.33

S32c. (IF NOT VERY/NOT AT ALL USEFUL) In what way is the UV index not that useful? [NEW] DO NOT READ - CODE ALL THAT APPLY

- ☐ No need for it
- ☐ Not necessary/climate doesn't require it
- ☐ Not very useful (PROBE FOR SPECIFICS)
- ☐ Do not understand it
- ☐ Do not spend time outdoors
- ☐ Stay well covered when outdoors
- ☐ Have to be outdoors anyway (exposure is unavoidable)
- ☐ Other (SPECIFY _____)
- ☐ Don't know/No answer

S33. And how easy do you feel it is to understand the UV index, that is what it means and how to make use of it? Is it . . .to understand? [NEW]

- ☐ Very easy
- ☐ Somewhat easy
- ☐ Not very easy
- ☐ Not at all easy
- ☐ Don't know/No answer

SKIP TO SECTION THREE

SECTION TWO B: FALL/SPRING

I would now like to know your opinions about the accuracy of various types of weather forecasts. Consider a fall or spring forecast that you might hear in October or March for your area.

F21a. Let's say that this forecast states the anticipated high for the day would be plus 1 degree Celsius. Suppose the actual high is not plus 1, but some temperature cooler than plus 1. At what temperature below plus 1 would you consider the forecast to be inaccurate? (ENSURE RESPONDENT GIVES ANSWER AS A TEMPERATURE, NOT AS A RANGE)

_____ temperature (in degrees Celsius)

☐ Don't know/No answer

F21b. Now suppose the actual high is not plus 1, but is some temperature warmer than plus 1. At what temperature above plus 1 would you consider the forecast inaccurate? (ENSURE RESPONDENT GIVES ANSWER AS A TEMPERATURE, NOT AS A RANGE)

_____ temperature (in degrees Celsius)

☐ Don't know/No answer

F22. How much importance do you place on the accuracy of fall or spring temperature forecasts? Would you say it is: [NEW]

- ☐ Very important (5)
- ☐ Important
- ☐ Neutral
- ☐ Unimportant
- ☐ Very unimportant (1)
- ☐ Don't know/No answer

F23. And how satisfied are you overall with the accuracy of fall or spring temperature forecasts provided? Are you: [NEW]

- ☐ Very satisfied (5)
- ☐ Satisfied
- ☐ Neutral
- ☐ Dissatisfied
- ☐ Very dissatisfied (1)
- ☐ Don't know/No answer

F24. Turning now to the accuracy of precipitation forecasts, say that "freezing rain" is forecast. Would you consider this forecast to be accurate or inaccurate if the precipitation was actually: READ AND ROTATE

		Accurate	Not Accurate	Don't know/ no answer
a.	Just rain	☐	☐	☐
b.	Just snow	☐	☐	☐
c.	A mix of snow and rain	☐	☐	☐
d.	Freezing drizzle	☐	☐	☐

F25. How much importance do you place on the accuracy of fall or spring precipitation forecasts? Would you say it is: [NEW]

- ☐ Very important (5)
- ☐ Important
- ☐ Neutral
- ☐ Unimportant
- ☐ Very unimportant (1)
- ☐ Don't know/No answer

F26. Which of the following parts of a fall or spring precipitation forecast is most important to you? Is it: [MODIFIED] READ AND ROTATE - CODE ONE ONLY

- ☐ The type of precipitation
- ☐ When it happen
- ☐ How much precipitation will fall
- ☐ The probability or chance that it will occur
- ☐ All equally important
- ☐ None of the above
- ☐ Other (SPECIFY _____)
- ☐ Don't know/No answer

F27. And how satisfied are you overall with the accuracy of fall or spring precipitation forecasts provided? Are you:

- ☐ Very satisfied (5)
- ☐ Satisfied
- ☐ Neutral
- ☐ Dissatisfied
- ☐ Very dissatisfied (1)
- ☐ Don't know/No answer

F28. Thinking now about wind during fall or spring, which of the following is most important to you in terms of a wind forecast? READ AND ROTATE - CODE ONE ONLY

- ☐ Wind speed
- ☐ Wind direction
- ☐ Wind chill
- ☐ All equally important SKIP TO Q.30
- ☐ None of the above SKIP TO Q.30
- ☐ Other (SPECIFY _____) SKIP TO Q.30
- ☐ Don't know/No answer SKIP TO Q.30

F29. You said that [Q.28 RESPONSE] is the most important aspect of wind for you. How satisfied are you with the accuracy of the weather information provided on [Q.28 RESPONSE]? Are you:

- ☐ Very satisfied (5)
- ☐ Satisfied
- ☐ Neutral
- ☐ Dissatisfied
- ☐ Very dissatisfied (1)
- ☐ Don't know/No answer

F30. Thinking now about sun and cloud during fall or spring, how satisfied are you with the accuracy of the weather forecasts provided for sun and cloud conditions? Are you:

- ☐ Very satisfied (5)
- ☐ Satisfied
- ☐ Neutral
- ☐ Dissatisfied
- ☐ Very dissatisfied (1)
- ☐ Don't know/No answer

F31. Now thinking about reduced visibility due to fog or heavy rain, how satisfied are you with the accuracy of the weather information provided on visibility conditions? Are you:

- ☐ Very satisfied (5)
- ☐ Satisfied
- ☐ Neutral
- ☐ Dissatisfied
- ☐ Very dissatisfied (1)
- ☐ Don't know/No answer

SKIP TO SECTION THREE

SECTION TWO C: WINTER

I would now like to know your opinions about the accuracy of various types of weather forecasts. Consider a winter forecast that you might hear in your area, say for January for your area.

W21a. Let's say that this forecast states the anticipated high for the day would be minus 5 degrees Celsius. Suppose the actual high is not minus 5, but some temperature cooler than minus 5. At what temperature below minus 5 would you consider the forecast to be inaccurate? (ENSURE RESPONDENT GIVES ANSWER AS A TEMPERATURE, NOT AS A RANGE)

_____ temperature (in degrees Celsius) ☐ Don't know/No answer

W21b. Now suppose the actual high is not minus 5, but is some temperature warmer than minus 5 At what temperature above minus 5 would you consider the forecast inaccurate? (ENSURE RESPONDENT GIVES ANSWER AS A TEMPERATURE, NOT AS A RANGE)

_____ temperature (in degrees Celsius) ☐ Don't know/No answer

W22. How much importance do you place on the accuracy of winter temperature forecasts? Would you say it is: [NEW]

- ☐ Very important (5)
- ☐ Important
- ☐ Neutral
- ☐ Unimportant
- ☐ Very unimportant (1)
- ☐ Don't know/No answer

F23. And how satisfied are you overall with the accuracy of winter temperature forecasts provided? Are you: [NEW]

- ☐ Very satisfied (5)
- ☐ Satisfied
- ☐ Neutral
- ☐ Dissatisfied
- ☐ Very dissatisfied (1)
- ☐ Don't know/No answer

W24. Turning now the accuracy of precipitation forecasts, say that "heavy snow" is forecast. Would you consider this forecast to be accurate or inaccurate if actually: READ IN SEQUENCE

		Accurate	Not Accurate	Don't Know
a.	The ground was slightly covered	☐	☐	☐
b.	There is some snow on the ground	☐	☐	☐
c.	There is snow on the streets that needs to be cleaned	☐	☐	☐
d.	Snow has piled up significantly	☐	☐	☐
e.	People are stranded because of the extreme amount of snow	☐	☐	☐

W25. How much importance do you place on the accuracy of winter precipitation forecasts? Would you say it is: [NEW]

- ☐ Very important (5)
- ☐ Important
- ☐ Neutral
- ☐ Unimportant
- ☐ Very unimportant (1)
- ☐ Don't know/No answer

W26. Which of the following parts of a winter precipitation forecast is most important to you? Is it: [MODIFIED] READ AND ROTATE - CODE ONE ONLY

- ☐ The type of precipitation
- ☐ When it happen
- ☐ How much precipitation will fall
- ☐ The probability or chance that it will occur
- ☐ All equally important
- ☐ None of the above
- ☐ Other (SPECIFY _____)
- ☐ Don't know/No answer

W27. And how satisfied are you overall with the accuracy of winter precipitation forecasts provided? Are you:

- ☐ Very satisfied (5)
- ☐ Satisfied
- ☐ Neutral
- ☐ Dissatisfied
- ☐ Very dissatisfied (1)
- ☐ Don't know/No answer

W28. Thinking now about wind during summer, which of the following is most important to you in terms of a [summer/fall/winter] forecast? READ AND ROTATE - CODE ONE ONLY

- ☐ Wind speed
- ☐ Wind direction
- ☐ Wind chill [WINTER ONLY]
- ☐ All equally important
- ☐ None of the above
- ☐ Other (SPECIFY _____) SKIP TO Q.30
- ☐ Don't know/No answer SKIP TO Q.30

W29. You said that [Q.42 RESPONSE] is the most important aspect of wind for you. How satisfied are you with the accuracy of the weather information provided on [Q.42 RESPONSE]? Are you:

- ☐ Very satisfied (5)
- ☐ Satisfied
- ☐ Neutral
- ☐ Dissatisfied
- ☐ Very dissatisfied (1)
- ☐ Don't know/No answer

W30. Thinking now about sun and cloud during the winter, how satisfied are you with the accuracy of the weather forecasts provided for sun and cloud conditions? Are you:

- ☐ Very satisfied (5)
- ☐ Satisfied
- ☐ Neutral
- ☐ Dissatisfied
- ☐ Very dissatisfied (1)
- ☐ Don't know/No answer

W31. Now thinking about reduced visibility due to fog or blowing snow, how satisfied are you with the accuracy of the weather information provided on visibility conditions? Are you:

- ☐ Very satisfied (5)
- ☐ Satisfied
- ☐ Neutral
- ☐ Dissatisfied
- ☐ Very dissatisfied (1)
- ☐ Don't know/No answer

Now I'd like to ask you a few questions about wind chill. . . .

W32a. How useful do you find wind chill information as part of winter weather forecasts? Is it: [NEW]

- ☐ Very useful SKIP TO Q.32
- ☐ Somewhat useful SKIP TO Q.32
- ☐ Not very useful
- ☐ Not at all useful
- ☐ Don't know/No answer SKIP TO Q.32

W32b. (IF NOT VERY/NOT AT ALL USEFUL) In what way is wind chill information not that useful? [NEW] DO NOT READ - CODE ALL THAT APPLY

- ☐ Not necessary/climate doesn't require it
- ☐ Not very useful (PROBE FOR SPECIFICS)
- ☐ Too complicated
- ☐ Do not understand it
- ☐ Temperature is more useful
- ☐ Other (SPECIFY _____)
- ☐ Don't know/No answer

W33. And how easy do you feel it is to understand the wind chill index, that is what it means and how to make use of it? Is it . . .to understand? [NEW]

- ☐ Very easy
- ☐ Somewhat easy
- ☐ Not very easy
- ☐ Not at all easy
- ☐ Don't know/No answer

SKIP TO SECTION THREE

SECTION THREE: WEATHER WARNINGS

I would now like to ask you specifically about weather warnings . . .

34. First of all, what do you think when you see or hear the words "Weather Warning" as part of a weather report? What does the term "Weather Warning" mean to you? DO NOT READ - CODE FIRST AND OTHER MENTIONS SEPARATELY - CODE UP TO SIX

- ☐ Extreme/severe conditions approaching/something unusual
- ☐ Pay attention/listen carefully/stay alert/keep updated on weather conditions
- ☐ Be prepared of oncoming bad weather/take precautions/action
- ☐ Very windy/high winds
- ☐ Disaster/danger/life threatening
- ☐ Information about driving conditions/dangerous driving conditions
- ☐ Important situation
- ☐ Very cold weather approaching
- ☐ May not be safe to travel/need to reschedule
- ☐ Don't go outdoors/stay inside
- ☐ Icing conditions
- ☐ Amount of precipitation
- ☐ Am not alarmed/not important
- ☐ Other (SPECIFY _____)
- ☐ Don't know/No answer

35. How important is Weather Warning information to you? Is it: [NEW]

- ☐ Very important (5)
- ☐ Important
- ☐ Neutral
- ☐ Unimportant
- ☐ Very unimportant (1)
- ☐ Don't know/No answer

36. From what source are you most likely to receive or hear about a Weather Warning? And are there any other sources are you likely to get such information? DO NOT READ - CODE FIRST AND OTHER MENTIONS SEPARATELY - CODE UP TO SIX

☐ Television - general mention (PROBE FOR SPECIFICS)
☐ Television - Weather network/Weather channel/Météomédia
☐ Television – Local TV station forecasts
☐ Television – bar running across bottom of screen/crawler
☐ Television – Local Environment Canada cable channel
☐ Radio – Local stations
☐ Newspaper
☐ Internet/web sites – non-specific
☐ Environment Canada web site/The Green Lane/Weather Office
☐ Weather Network web site
☐ Personal digital assistant (Palmpilot/Blackberry)
☐ E-mail
☐ WeatherRadio Canada
☐ WeatherCopy Canada
☐ Environment Canada (PROBE FOR SPECIFICS)
☐ Telephone - general mention (PROBE FOR SPECIFICS)
☐ Telephone - 1-800 number
☐ Telephone - 1-900 number
☐ Environment Canada - recorded tape
☐ Family member/friend/Word of mouth
☐ None
☐ Other (SPECIFY _____)
☐ Don't know/No answer

RANDOMLY DIVIDE SAMPLE INTO SUMMER AND WINTER SECTIONS

Summer Warning

I would now like to you think about a summer weather situation, such as an approaching severe thunderstorm with possible hail or even tornadoes, in which you hear that a Weather Warning is in effect.

S37. Of all of the times that you have heard a summer severe weather warning in your area, how often does a storm actually occur in your area? Would you say that it occurs:

☐ Always
☐ Most of the time
☐ About half of the time
☐ Less than half the time
☐ Rarely
☐ Never
☐ Never heard storm warnings SKIP TO Q.44
☐ Don't know/No answer SKIP TO Q.44

S38. And how often would you say that you receive enough notice in order to properly react to a warning about an approaching thunderstorm heading toward your area? Would you say it is:

☐ Always
☐ Most of the time
☐ About half of the time
☐ Less than half the time
☐ Rarely
☐ Never
☐ Don't know/No answer

S39. When you hear a summer warning for something like a severe thunderstorm or tornado, how much advance notice do you need? DO NOT READ - RECORD IN MINUTES

___ Minutes
☐ Other (SPECIFY _____)
☐ Don't know/No answer

S40. Overall, how satisfied are you with the summer warning information you receive for your area? Are you: [NEW]

- ☐ Very satisfied SKIP TO Q.42
- ☐ Satisfied SKIP TO Q.42
- ☐ Neutral SKIP TO Q.42
- ☐ Dissatisfied
- ☐ Very dissatisfied
- ☐ Don't know/No answer SKIP TO Q.42

S41. (IF DISSATISFIED) In what way are you dissatisfied with the Weather Warning information you receive? DO NOT READ – CODE ALL THAT APPLY

- ☐ Not enough information/detailed information (PROBE FOR SPECIFICS)
- ☐ Not enough information on type of damage likely
- ☐ Not enough information on start/end time
- ☐ Not enough advance notice
- ☐ Not accurate (forecast doesn't predict what actually happens)
- ☐ Too much detail/information
- ☐ Other (SPECIFY _____)
- ☐ Don't know/No answer

S42. I would like to know about the type of information provided in summer Weather Warnings. I will read to you several aspects of a severe thunderstorm warning and in each case please tell me whether you think this type of information is generally presented very clearly, somewhat clearly, not very clearly, or not at all clearly? Starting with . . . READ AND ROTATE ASPECTS

		Very clearly	Somewhat clearly	Not very clearly	Not at all clearly	Information not available/provided	Don't know/ no answer
a.	The area likely to be affected by the storm	☐	☐	☐	☐	☐	☐
b.	The severity of the storm	☐	☐	☐	☐	☐	☐
c.	When the storm will arrive in your area	☐	☐	☐	☐	☐	☐
d.	How long the storm is expected to last	☐	☐	☐	☐	☐	☐
e.	The type of damage that could result from the storm	☐	☐	☐	☐	☐	☐

S43. REMOVED

SKIP TO SECTION FOUR

Winter Warning

I would now like to you think about a winter storm weather situation, such as an approaching blizzard, in which you hear that a Weather Warning is in effect.

W37. Of all of the times that you have heard a winter storm warning in your area, how often does a storm actually occur in your area? Would you say that it occurs:

- ☐ Always
- ☐ Most of the time
- ☐ About half of the time
- ☐ Less than half the time
- ☐ Rarely
- ☐ Never
- ☐ Never heard storm warnings SKIP TO Q.44
- ☐ Don't know/No answer SKIP TO Q.44

W38. And how often would you say that you receive enough notice in order to properly react to a warning about an approaching winter storm heading toward your area? Would you say it is:

- ☐ Always
- ☐ Most of the time
- ☐ About half of the time
- ☐ Less than half the time
- ☐ Rarely
- ☐ Never
- ☐ Don't know/No answer

W39. When you hear a winter storm warning, how much advance notice do you need? DO NOT READ - RECORD IN HOURS

___ Hours
☐ Other (SPECIFY _____)
☐ Don't know/No answer

W40. Overall, how satisfied are you with the winter storm warning information you receive for your area? Are you: [NEW]

☐ Very satisfied SKIP TO Q.42
☐ Satisfied SKIP TO Q.42
☐ Neutral SKIP TO Q.42
☐ Dissatisfied
☐ Very dissatisfied
☐ Don't know/No answer SKIP TO Q.42

W41. (IF DISSATISFIED) In what way are you dissatisfied with the Weather Warning information you receive? DO NOT READ – CODE ALL THAT APPLY

☐ Not enough information/detailed information (PROBE FOR SPECIFICS)
☐ Not enough information on type of damage likely
☐ Not enough information on start/end time
☐ Not enough advance notice
☐ Not accurate (forecast doesn't predict what actually happens)
☐ Too much detail/information
☐ Other (SPECIFY _____)
☐ Don't know/No answer

W42. I would like to know about the type of information provided in winter storm Weather Warnings. I will read to you several aspects of a storm warning and in each case please tell me whether you think this type of information is generally presented very clearly, somewhat clearly, not very clearly, or not at all clearly? Starting with . . . READ AND ROTATE ASPECTS

		Very clearly	Somewhat clearly	Not very clearly	Not at all clearly	Don't know/ no answer
a.	The area likely to be affected by the storm	☐	☐	☐	☐	☐
b.	The severity of the storm	☐	☐	☐	☐	☐
c.	When the storm will arrive in your area	☐	☐	☐	☐	☐
d.	How long the storm is expected to last	☐	☐	☐	☐	☐
e.	The type of damage that could result from the storm	☐	☐	☐	☐	☐

W43. REMOVED

SECTION FOUR: ENVIRONMENT CANADA SERVICES

I would now like to ask you about who provides weather-related services and information. . .

45. As you may or may not know, Environment Canada, a department of the federal government, is the principal provider of weather information in Canada. Can you tell me they types of weather-related services Environment Canada provides? DO NOT READ – CODE FIRST AND OTHER MENTIONS SEPARATELY – CODE UP TO SIX; PROBE: Any others?

☐ Weather forecasts
☐ Provide weather information to media
☐ Radio/TV broadcasts
☐ Issue storm warnings
☐ Road/highway conditions
☐ Temperature readings/forecasts
☐ Amount of precipitation (snow/rain)
☐ Air quality information
☐ Airport forecasts/flying conditions
☐ Farm/rural forecasts
☐ Monitor weather/research
☐ Long range forecasts/3-5 day forecasts
☐ Ski conditions
☐ Telephone recorded messages
☐ Weather web site
☐ WeatherRadio

- ☐ Humidity levels/humidex
- ☐ Environment related issues/pollution/recycling
- ☐ Marine forecasts
- ☐ Snow/rain conditions
- ☐ Wind information (speed, direction)
- ☐ Wind chill index
- ☐ UV ratings
- ☐ Weather changes/updates
- ☐ WeatherCopy Radio
- ☐ Local weather offices/stations
- ☐ Historical weather information/statistics
- ☐ Satellite information
- ☐ Climate information/data
- ☐ Other (SPECIFY _____)
- ☐ Don't know/No answer

I'd like to ask you about various weather services that are available from Environment Canada, either by phone or electronically . . .

Free Recorded Local Weather Messages/ATADS

46. In most major urban centres, Environment Canada provides a free 24 hour recorded local weather forecast, accessible only over the telephone. Callers in the local dialling area do not pay any charges. However, those calling from outside the local area must pay long distance charges to hear about weather that affects their area. Are you aware of this Environment Canada recorded weather forecast message accessible over the phone?

- ☐ Yes
- ☐ No SKIP TO Q.53
- ☐ Don't know/No answer SKIP TO Q.53

47. (IF YES) Have you ever used this service?

- ☐ Yes
- ☐ No SKIP TO Q.53
- ☐ Don't know/No answer SKIP TO Q.53

48. (IF YES) How often do you use this service? Would it be: READ

- ☐ More than once a day
- ☐ Once a day
- ☐ Two or more times per week
- ☐ Once a week
- ☐ Two or more times per month
- ☐ Once a month
- ☐ Less than once a month
- ☐ Have never used SKIP TO Q.53
- ☐ Don't know/No answer

49. And how often, if at all, do you try to call this weather line and receive a busy signal? Is it:

- ☐ Always
- ☐ Most of the time
- ☐ About half the time
- ☐ Less than half of the time
- ☐ Rarely or never
- ☐ Don't know/No answer

50. How important is this service to you as a source of weather forecast information? Is it: [NEW]

- ☐ Very important (5)
- ☐ Important
- ☐ Neutral
- ☐ Unimportant
- ☐ Very unimportant (1)
- ☐ Don't know/No answer

51. How satisfied are you with the recorded weather messages provided by Environment Canada? Are you:

- ☐ Very satisfied (5)
- ☐ Satisfied
- ☐ Neutral
- ☐ Dissatisfied
- ☐ Very dissatisfied (1)
- ☐ Don't know/No answer

52. For budgetary reasons, Environment Canada cannot provide this service free of long distance charges. Do you think Environment Canada should: READ IN SEQUENCE - CODE ONE ONLY

☐ Keep the service as it currently is, with local calls being free, but others paying long distance where applicable, or
☐ Require everyone to pay, even for local calls
☐ Other (SPECIFY _____)
☐ Don't know/No answer

1-900 User-Pay Telephone Services

53. Environment Canada also has a national 1-900 user-pay telephone service called "Weather One on One", which allows the caller to speak directly with an Environment Canada meteorologist. Are you aware of this 1-900 user-pay telephone service?

☐ Yes
☐ No SKIP TO Q.59
☐ Don't know/No answer SKIP TO Q.59

54. Have you ever used this service?

☐ Yes
☐ No SKIP TO Q.59
☐ Don't know/No answer SKIP TO Q.59

55. (IF YES) How often do you use this service? Would it be: READ

☐ More than once a day
☐ Once a day
☐ Two or more times per week
☐ Once a week
☐ Two or more times per month
☐ Once a month
☐ Less than once a month
☐ Only once or twice
☐ Don't know/No answer

56. How important is this service to you as a source of weather forecast information? Is it: [NEW]

☐ Very important (5)
☐ Important
☐ Neutral
☐ Unimportant
☐ Very unimportant (1)
☐ Don't know/No answer

57. How satisfied are you with the 1-900 telephone service provided by Environment Canada? Are you:

☐ Very satisfied (5)
☐ Satisfied
☐ Neutral
☐ Dissatisfied
☐ Very dissatisfied (1)
☐ Don't know/No answer

58. The cost of this service is $2.99 per minute. For the type of information provided, do you think the price offers excellent, good, only fair or poor value for money? [MODIFIED]

☐ Excellent value
☐ Good value
☐ Only fair value
☐ Poor value
☐ Depends
☐ Don't know/No answer

WEATHERADIO

59. WEATHERADIO is another Environment Canada service that broadcasts weather information 24 hours a day in many areas across Canada. A special radio receiver must be purchased to receive these weather broadcasts.

Are you aware of this WEATHERADIO service?

- ☐ Yes
- ☐ No SKIP TO Q.64
- ☐ Don't know/No answer SKIP TO Q.64

60. Have you ever used this service?

- ☐ Yes
- ☐ No SKIP TO Q.64
- ☐ Don't know/No answer SKIP TO Q.64

61. (IF YES) How often do you use this service? Would it be: READ

- ☐ More than once a day
- ☐ Once a day
- ☐ Two or more times per week
- ☐ Once a week
- ☐ Two or more times per month
- ☐ Once a month
- ☐ Less than once a month
- ☐ Only once or twice
- ☐ Have never used
- ☐ Don't know/No answer

62. How important is this WEATHERADIO service to you as a source of weather forecast information? Is it: [NEW]

- ☐ Very important (5)
- ☐ Important
- ☐ Neutral
- ☐ Unimportant
- ☐ Very unimportant (1)
- ☐ Don't know/No answer

63. How satisfied are you with the WEATHERADIO service weather messages provided by Environment Canada? Are you:

- ☐ Very satisfied (5)
- ☐ Satisfied
- ☐ Neutral
- ☐ Dissatisfied
- ☐ Very dissatisfied (1)
- ☐ Don't know/No answer

Internet Web Pages

64. Environment Canada maintains an Internet web site that provides many types of weather and environmental information. Are you aware of Environment Canada's weather web site?

- ☐ Yes
- ☐ No SKIP TO Q.70
- ☐ Don't know/No answer SKIP TO Q.70

65. (IF YES) How often do you use this service? Would it be: READ

- ☐ More than once a day
- ☐ Once a day
- ☐ Two or more times per week
- ☐ Once a week
- ☐ Two or more times per month
- ☐ Once a month
- ☐ Less than once a month
- ☐ Only once or twice
- ☐ Have never used
- ☐ Don't know/No answer

66. How important is this Environment Canada web site to you as a source of weather forecast information? Is it: [NEW]

- ☐ Very important (5)
- ☐ Important
- ☐ Neutral
- ☐ Unimportant
- ☐ Very unimportant (1)
- ☐ Don't know/No answer

67. How satisfied are you with this web site as a source of weather forecast information? Are you:

- ☐ Very satisfied (5)
- ☐ Satisfied
- ☐ Neutral
- ☐ Dissatisfied
- ☐ Very dissatisfied (1)
- ☐ Don't know/No answer

68. Do you use any other web sites for weather information? [NEW]

- ☐ Yes
- ☐ No SKIP TO Q.70
- ☐ Don't know/No answer SKIP TO Q.70

69. (IF YES) Which other web sites do you use for weather information? [NEW] DO NOT READ - CODE ALL THAT APPLY

- ☐ Environment Canada – general/non-specific
- ☐ WeatherNetwork Météomédia
- ☐ Yahoo
- ☐ Sympatico
- ☐ CBC
- ☐ Other (SPECIFY _____)
- ☐ Don't know/No answer

70. REMOVED

And on another aspect . . .

71. Who do you feel should be responsible for providing weather services and forecasting information to Canadians? Do you think it should be provided: [NEW] READ IN SEQUENCE - CODE ONE ONLY

- ☐ Primarily by the government
- ☐ Primarily by private companies
- ☐ By a mix of government and private companies
- ☐ Both equally
- ☐ Other (SPECIFY _____)
- ☐ Neither
- ☐ Don't know/No answer

72. In the past two years, have you contacted Environment Canada to make comments or to get specific information other than regular weather information? [NEW]

- ☐ Yes
- ☐ No SKIP TO Q.75
- ☐ Don't know/No answer SKIP TO Q.75

73. (IF YES) How did you contact Environment Canada? [NEW] READ CATEGORIES IF NECESSARY - CODE ALL THAT APPLY

- ☐ By telephone (PROBE FOR SPECIFICS)
- ☐ By telephone – 1-900 number
- ☐ By telephone – 1-800 number
- ☐ By telephone – Called weather office
- ☐ By telephone – other (SPECIFY _____)
- ☐ By e-mail
- ☐ Environment Canada web site
- ☐ 1-800 O Canada web site/federal gov't web site
- ☐ Environment Canada Enquiries Centre
- ☐ Other (SPECIFY _____)
- ☐ Don't know/No answer SKIP TO Q.75

74. How satisfied were you with your most recent contact with Environment Canada? [NEW]

- ☐ Very satisfied (5)
- ☐ Mostly satisfied
- ☐ Somewhat satisfied
- ☐ Not very satisfied
- ☐ Not at all satisfied (1)
- ☐ Don't know/No answer

75. How interested would you be in getting information on the accuracy record of Environment Canada weather forecasts for your area? Would you be: [NEW]

- ☐ Very interested
- ☐ Somewhat interested
- ☐ Not very interested
- ☐ Not at all interested
- ☐ Depends
- ☐ Don't know/No answer

SECTION FIVE: RESPONDENT CHARACTERISTICS/DEMOGRAPHICS

To finish up, I'd like to ask you a few questions about you and your household for statistical purposes only. Please be assured that your answers will remain completely confidential.

76. In which of the following age categories can I place you? READ

- ☐ 18 to 24
- ☐ 25 to 34
- ☐ 35 to 44
- ☐ 45 to 54
- ☐ 55 to 64
- ☐ 65 and over
- ☐ No Response/Refused

77. What is your mother tongue, that is, the language you first learned at home? [NEW] DO NOT READ - CODE ONE ONLY

- ☐ English
- ☐ French
- ☐ Other (SPECIFY _____)
- ☐ No response/Refused

78. What is the highest level of education you have completed? READ IF NECESSARY - CODE ONE ONLY

- ☐ Elementary school
- ☐ Some high school
- ☐ Completed high school
- ☐ Some community college/technical college/CEGEP
- ☐ Completed community college/technical college/CEGEP
- ☐ Some university
- ☐ Completed university (undergraduate)
- ☐ Post-graduate degree
- ☐ No schooling
- ☐ No response/Refuse

79. Do you currently have access to the Internet, either at home or at work? [NEW] CODE ALL THAT APPLY

- ☐ Access at home
- ☐ Access at work
- ☐ Access at both home and work
- ☐ Access somewhere else (library)
- ☐ Don't know/No answer

80. And for statistical purposes only, we need information about your household income. Please tell me which of the following categories applies to your total household income for the year 2001? READ - CODE ONE ONLY

- ☐ Less than $25,000
- ☐ $25,000 to $40,000
- ☐ $40,000 to $60,000
- ☐ $60,000 to $80,000
- ☐ More than $80,000
- ☐ Don't know/Refused

81. And finally, may I have the first three digits of your postal code? [NEW] (NEW BRUNSWICK ONLY:) And finally, may I have the six digits of your postal code?
RECORD
____ _____ _____

This completes the survey. In case my supervisor would like to verify that I conducted this interview, may I have your first name?

First Name: _____

On behalf of Environment Canada, thank you very much for your cooperation.

RECORD:

82. Province

☐ Alberta
☐ British Columbia
☐ Manitoba
☐ New Brunswick
☐ Newfoundland
☐ Nova Scotia
☐ Ontario
☐ Prince Edward Island
☐ Quebec
☐ Saskatchewan

83. Gender

☐ Male
☐ Female

84. Language of interview

☐ English
☐ French

APPENDIX D

REFERENCES ON THE ECONOMIC VALUE OF METEOROLOGICAL SERVICES

Adamowicz, W., J. Louviere, and M. Willians. 1994 Combining Revealed and Stated Preference Methods For Valuing Environmental Amenities. *Journal of Environmental Economics and Management*.

Adamowicz, W.L., J. Swait, P. Boxall, J. Louviere, and M. Willians. 1997. Perceptions versus Objective Measures of Environmental Quality in Combined Revealed and Stated Preference Models of Environmental Valuation. J*ournal of Environmental Economics and Management*.

Anaman, K.A., D.J. Thampapillai, A. Henderson-Sellers, P.F. Noar, and P.J. Sullivan. 1995. Methods for Assessing the Benefits of Meteorological Services in Australia. *Meteorological Applications*.

Anaman, K.A., S.C. Lellyett, L. Drake, R.J. Leigh, A. Henderson-Sellers, P.F. Noar, P.J. Sullivan and D.J. Thampapillai. 1998. Benefits of Meteorological Services: Evidence from Recent Research in Australia. *Meteorological Applications*.

Brown, Jeremy. 2002. *The Value of Weather Forecast Services*. Masters Thesis submitted to University of Guelph, Guelph,ON.

Carson, R.T., N.E. Flores, K.M. Martin, J.L. Wright. 1996. Contingent Valuation and Revealed Preference Methodologies: Comparing the Estimates for Quasi-Public Goods. *Land Economics*.

Cummings, R.G., D.S. Brookshire, and W. Schulze, 1986. *Valuing Environmental Goods: An Assessment of the Contingent Valuation Method*. Rowan and Allanheld, Totowa, NJ.

Freebairn, John W., John W. Zillman. 2002. Economic Benefits of Meteorological Services. *Meteorological Applications*.

Freeman, A.M. 1993. *The Measurement of Environmental and Resource Values: Theory and Methods. Resources for the Future*, Washington, DC.

Hilton, R.W. 1981. The Determinants of Information Value: Synthesizing Some General Results. *Management Science.*

Hooke, W.H. and R.A. Pielke, Jr. 2000. *Short Term Weather Prediction: An Orchestra in Need of a Conductor*. In *Prediction: Decision-Making and the Future of Nature,* D. Sarewitz, R.A. Pielke, Jr., and R. Byerly, Jr. (eds.). Island Press, Washington, DC.

Johnson, S.R. and M.T. Holt. 1997. "*The Value of Weather Information.* Chapter 3 in *Economic Value of Weather and Climate Forecasts*, R.W. Katz and A.H. Murphy (eds). Cambridge University Press, Cambridge. U.K.

Katz, R.W. and A.H. Murphy (eds). 1997. Economic Value of Weather and Climate Forecasts. Cambridge University Press, Cambridge. U.K.

Lazo, Jeffrey K., June 2000. *Economic Value of Improved weather Forecasts: A Pilot Study of Denver Households*. Stratus Consulting Inc. Boulder CO.

Mitchell, R.C., R.T. Carson. 1989. *Using Surveys to Value Public Goods: The Contingent Valuation Method.* Resources for the Future, Washington, DC.

Mjelde, J.W., S.T. Sonka, and D.S. Peel. 1989. *The Socioeconomic Value of Climate and Weather Forecasting: A Review*. Research report 89-01. Midwestern Climate center, Illinois State Water Survey, Champaign

Murphy, A.H. 1994. *Socio-Economic Value of Climate Forecasts*. Report to Economics Group, Office of the Chief Scientist, National Oceanic and Atmospheric Administration.

Purves, Glenn T., 1997: *Economic Aspects of AES Marine Weather Services in Marine Applications*, A Case Study of Atlantic Canada. Dalhousie University.

Rollins, Kimberly, J. Shaykewich, 1997: *Cross-Sector Economic Valuation of Weather Information Dissemination Services: Two Applications Using the Contingent Valuation Method*. University of Guelph.

Stewart, T.R. 1997. *Forecast Value: Descriptive Decision Studies*. Chapter 5 in *Economic Value of Weather and Climate Forecasts*, R.W. Katz and A.H. Murphy (eds). Cambridge University Press, Cambridge. U.K.

Turner, Jason R., 1996: V*alue of Weather Forecast Information for Dry Hay and Winter Wheat Production in Ontario*. University of Guelph.

APPENDIX E
CANADIAN AUTOMATED WARNING PERFORMANCE MEASUREMENT SYSTEM

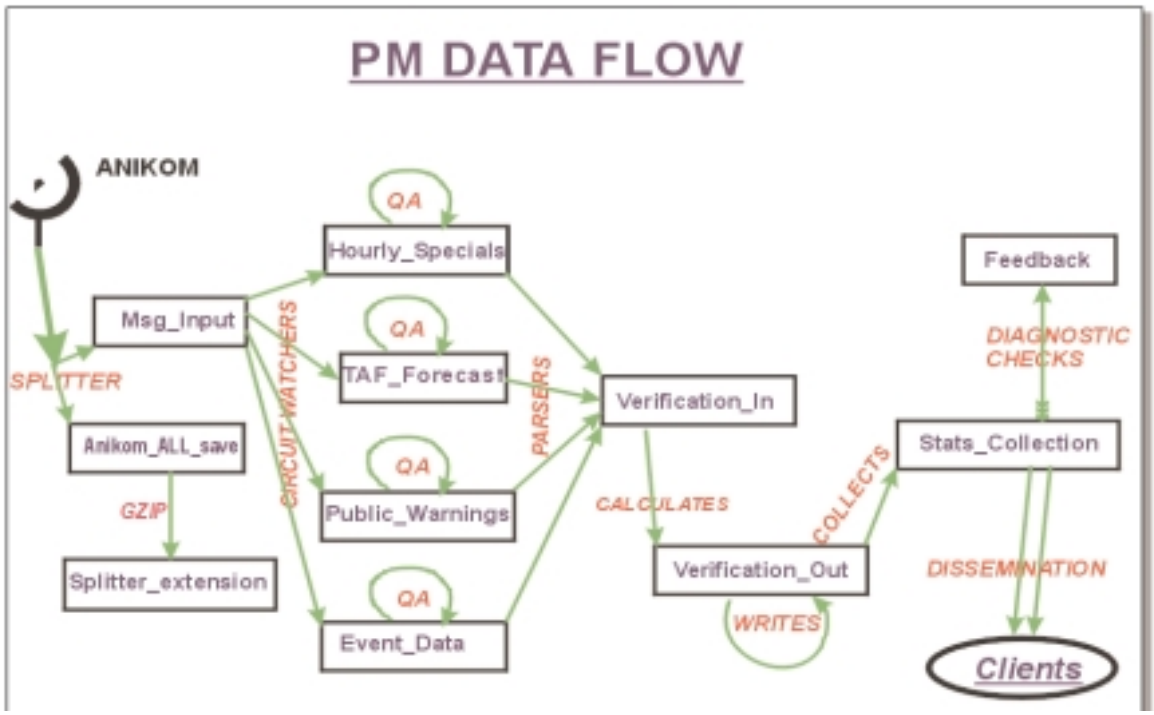


Figure E1 A System Independent from Forecast Operations

PM DATA FLOW … METEOROLOGICAL SERVICE OF CANADA …
AVIATION TAF & PUBLIC WEATHER WARNING PERFORMANCE MEASUREMENT

A) Raw data arrives via the Anikom telecommunication system through two independent feeds. This data is input for the Splitter software, which performs two functions:
   i) Output (the raw data) is stored (real time) in the anikom_ALL_save database. After twelve days these files are compressed and moved to the splitter_extension database.
   ii) Output is real time METARs, TAFs and Public Weather Warnings, which are stored in the Msg_Input database.

B) This data is read (at a data dependent interval) by the Circuit Watcher software. Each data type is placed into a corresponding type database (Hourly, Forecast, and Public_Warnings). This data is then quality controlled by its corresponding QA software.

C) The QA'd data is read by the Parser software. The output produced is client dependent data (meta data) that will be used for statistical calculations. This is stored in the Verification_In database.

D) This meta data is read by the Calculate software. The Calculate software compares each TAF/METAR combination on a particular day, for a particular station, and for a particular client for the 1st 6 hours of every TAF. The output is stored in the Verification_Out database.

E) This data is read by the Write software, which produces summaries of this data. The summaries are with reference to a particular period (30 and 90 days), statistic category (i.e. ALT_FAR), station, and client. This summary data is also stored in the Verification_Out database.

F) The summary data is read by the Collect software, which sums the summary data for a particular period, statistic category, station, and client to produce a report. These reports are located in the Stats_Collection database.

G) The reports are read by the Diagnostic Check software, which compares the values contained in the reports to established normals. If a value lies outside of its "normal value" range, the PMO team is notified via e-mail.

H) The reports are then disseminated to various clients via e-mail and made available to operational staff via an internal web site.

APPENDIX F
CANADIAN AUTOMATED ROUTINE PUBLIC FORECAST PERFORMANCE MEASUREMENT SYSTEM

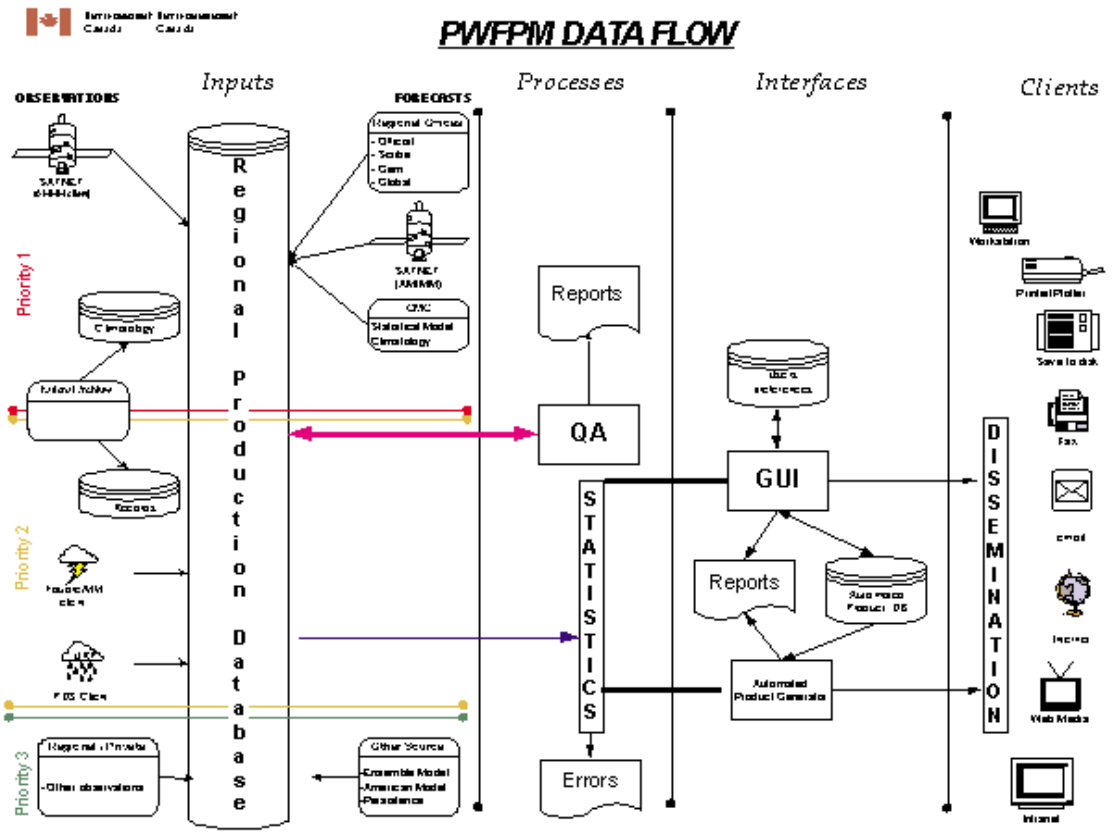


Figure F1 A System Integrated with Forecast Operations

PUBLIC WEATHER FORECAST PERFORMANCE MEASUREMENT PROJECT (PWFPM)

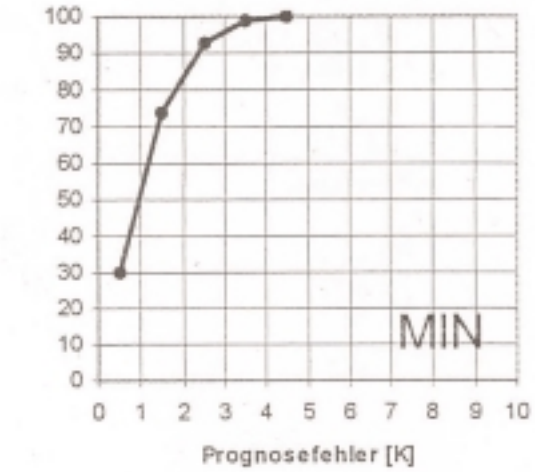
An automatic national public weather forecast performance measurement system with three main objectives:

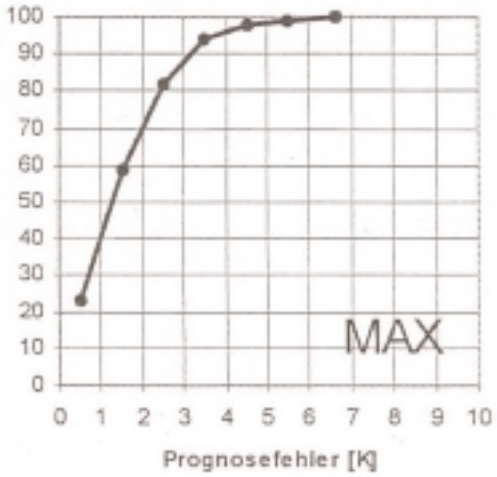
- To provide national ongoing reports to the public of our forecast performance.
- To provide forecasters with information on where they add significant value, in order for them to concentrate their efforts on these cases or parameters.
- To provide statistical information on the performance of the Canadian public forecast program to regional and national managers who administrate the program.

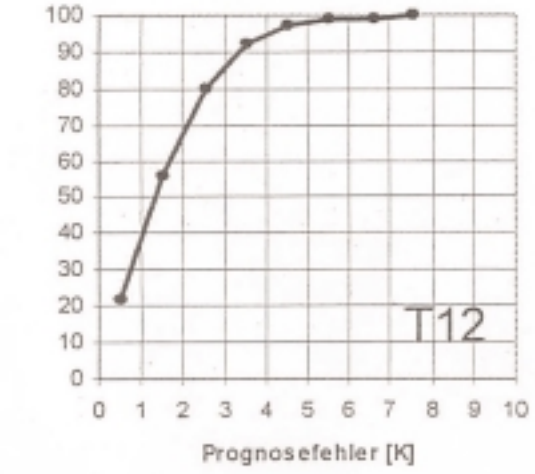
APPENDIX G

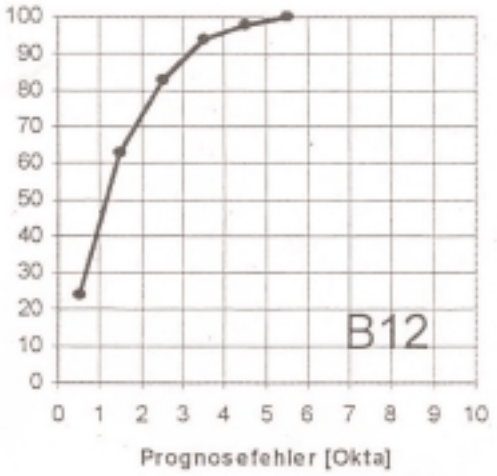
PERFORMANCE AT VARYING LEVELS OF ACCURACY

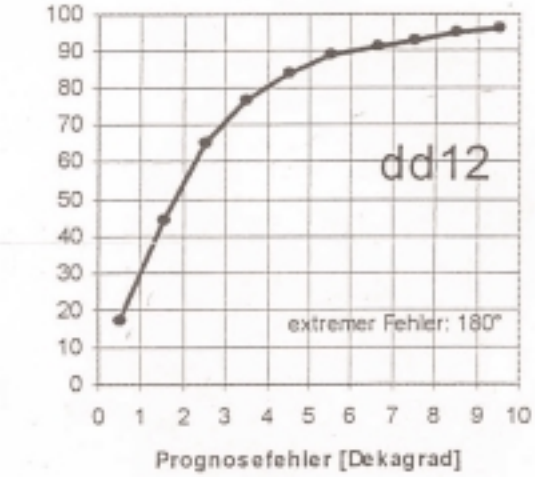
MIN = Temperaturminimum morgen (früh), **MAX** = Temperaturmaximum morgen
T12 = Temperatur morgen 12 UTC, **B12** = Bedeckungsgrad mit Wolken, morgen 12 UTC
dd12 = Windrichtung morgen 12 UTC, nur dann verifiziert, wenn ff12 (beobachtet) ≥ 3 m/s
ff12 = Windgeschwindigkeit morgen 12 UTC

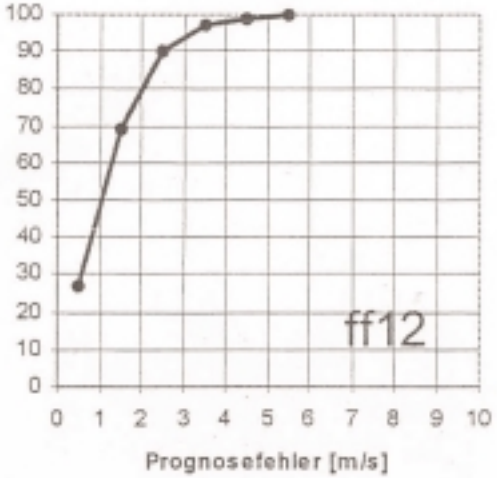












APPENDIX H

RENEWAL OF THE NORTH AMERICAN WIND CHILL PROGRAM

The renewal of the Wind Chill Program in North America took a fairly lengthy and rigorous process route. The two main objectives of the program were that of bringing into the program the latest available science while at the same time creating a forecast product that was easily understood and effective in providing citizens with useable information. The process started with some negative feedback, some via the public media, on the accuracy and the usability of the program. This was responded to by some public opinion research (surveys and focus groups) in Canada. It was discovered that while there was a widely held view that wind chill was a very important forecast element for the cold season there was a feeling that the severity was overstated in forecasts and warnings and the program, in Canada at least, was presented in a confusing manner thereby limiting its usefulness.

A literature review was undertaken and published. An Internet Workshop on Wind Chill followed this with extensive international participation and papers from international experts solicited. With this level of interest raised the International Society of Biometeorology established Commission 6 on a Universal Thermal Climate Index. Shortly thereafter the US Office of the Federal Coordinator of Meteorology established a Joint Action Group on Thermal Indices (JAG/TI) with representation from the US Federal Government, the Canadian Federal Government and known experts in the universities and other communities. The first goal of the JAG/TI was to upgrade and standardize the index used for determining wind chill impact. This stimulated collaboration on additional research including trials on human subjects that were undertaken at the Defense R&D Canada climate chamber facilities. This research produced a new equation for Wind Chill using a temperature scale.

With a new equation in hand a forecasting program had to be rebuilt in Canada and the United States along with a public education program. The public education program was helped by a high degree of media attention. Once the new equation was made available both the new forecasting program and standards and the educational program were developed and implemented in a time interval of three months. The rapidity with which it was possible to implement a renewed program benefited greatly from the rigorous process that preceded it. This was, indeed, a good example where positive international collaboration assisted in the development and implementation of a common program.

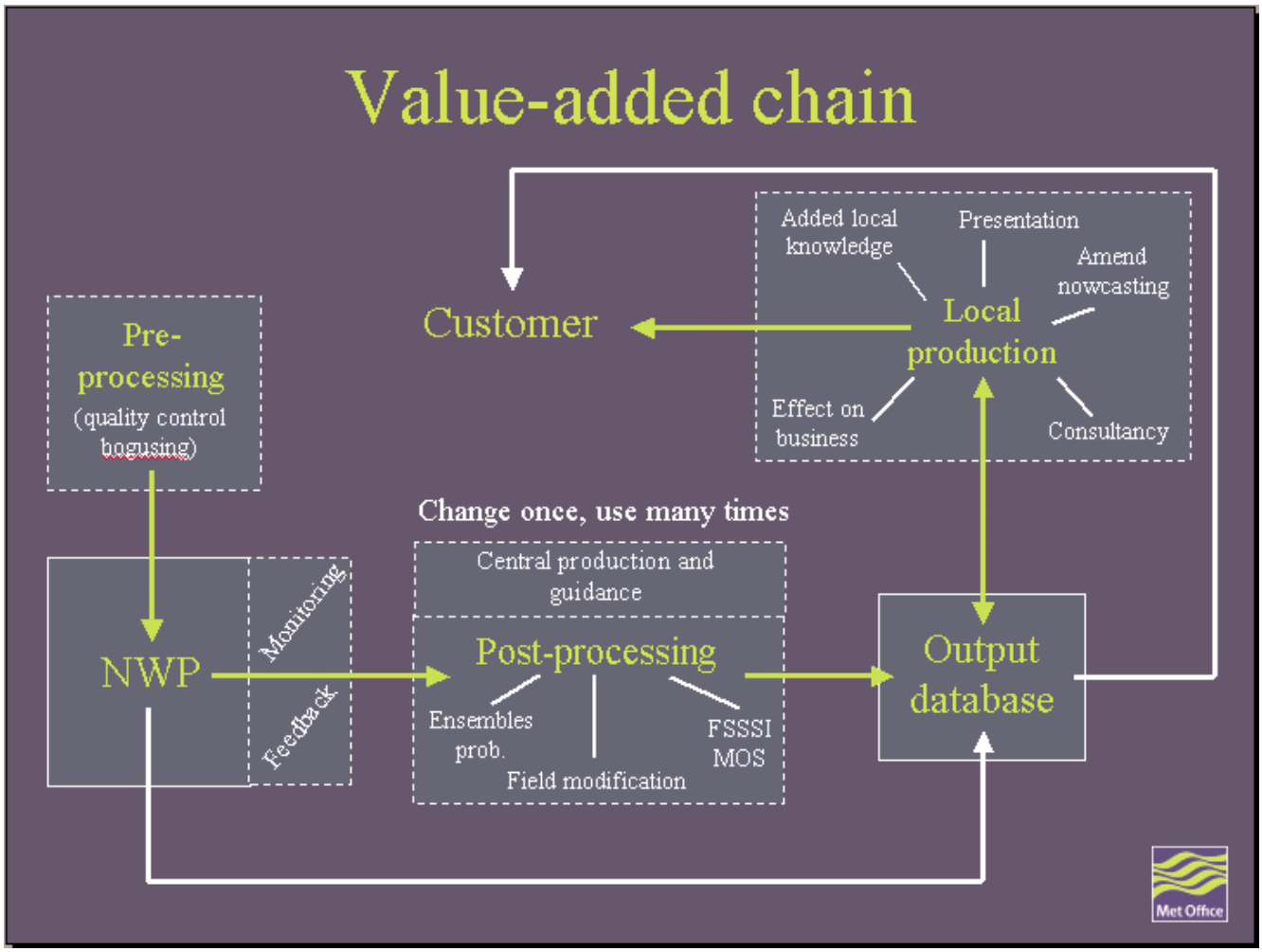
Large variations in the climate of the different regions of Canada made setting warning levels problematic, especially after observing much variability in individual response to wind chill during the human trials. Accommodation was made, with regard to human adaptation, - behavioural and physiological - to local climate regimes. The media and the general public required an enhanced understanding of the impact of wind chill so another problem addressed was the use of “minutes to freeze” included in warning messages. Since individual variability was shown to be quite high, the decision was made to focus on the more vulnerable proportions of the population. This most vulnerable portion is based on the most susceptible 5% from the human trials. Accordingly, new procedures for forecast and reporting operations were implemented and a public education program tailored to address these aspects.

It is important to note that the approach currently adopted in the North American context is one of continuous improvement in that further research on ‘minutes to freeze’ and radiation effects will result in further future modifications to the program. A review of the first winter of operation of the renewed wind chill program undertaken in the spring of 2002 along with further human trials will allow for further refinement of the minutes to freeze and its customization for the different climatic regimes of Canada. If information of the effect of wind chill on infants, children and the elderly becomes available, it too will be incorporated into the wind chill program.

More information on the wind chill program in Canada can be found at the following web site: http://www.msc.ec.gc.ca/windchill/index_e.cfm. Also at this site charts, on-line calculators and downloadable calculators are available.

APPENDIX I

THE MET OFFICE "ADDED VALUE CHAIN"



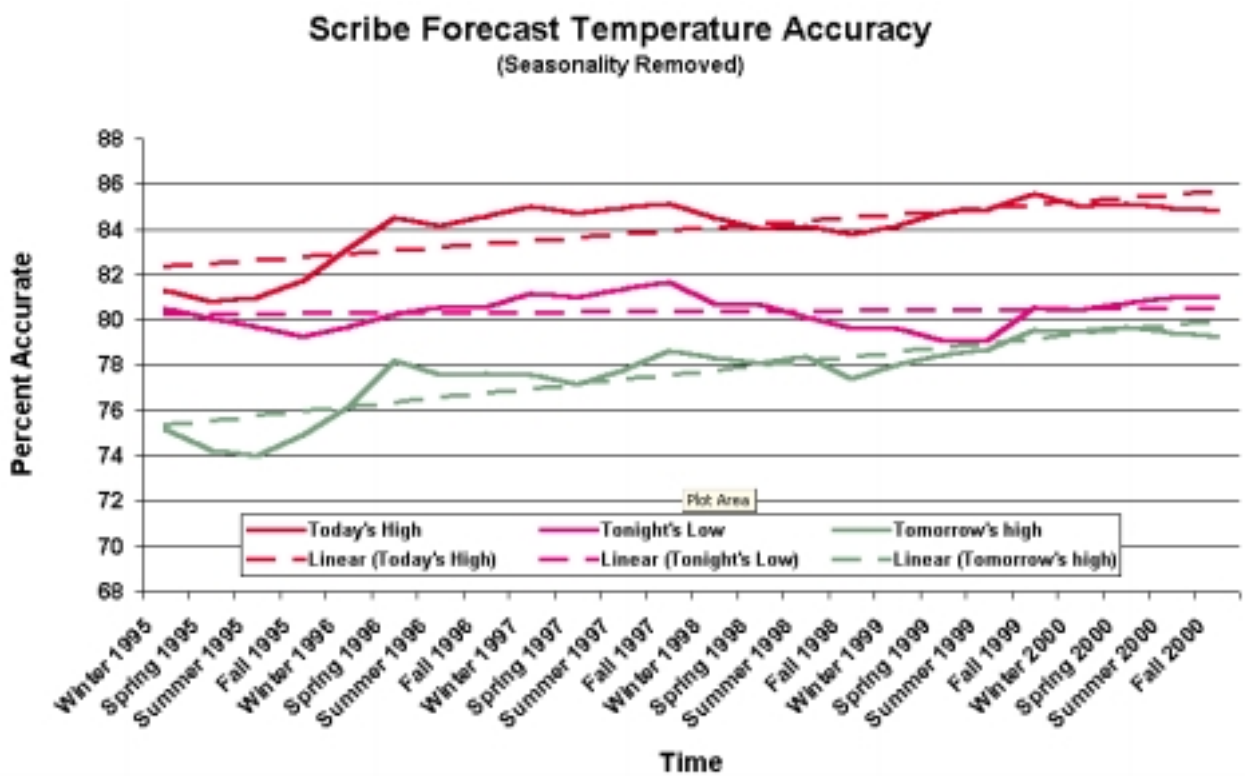
Moving through the value chain from raw NWP and pre-processing to post processing and eventually the customer through one data base that may also include raw products for those that want them such as upper winds for Aviation. Meteorological observations, if included, would be a box before NWP.

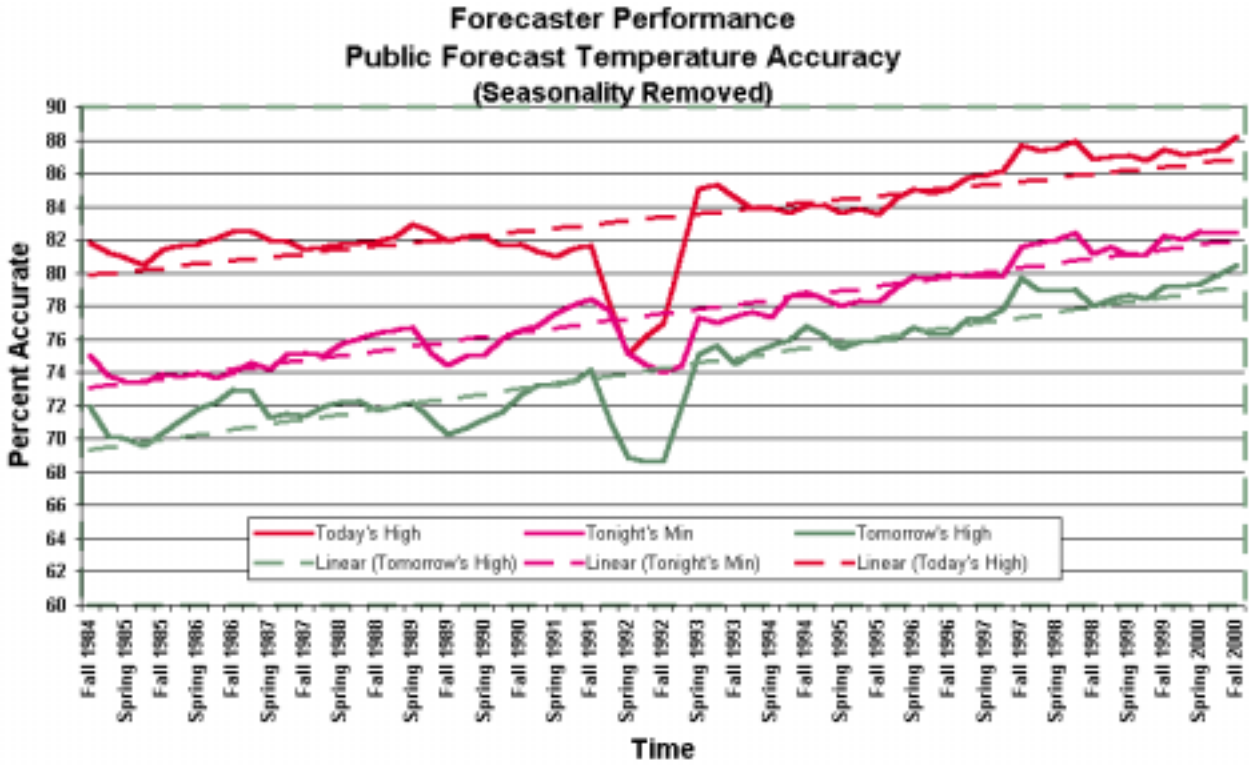
Post processing is the most interesting area that should help overcome known model deficiencies such as boundary layer problems. Doctoring high enough up in the stream can save duplication downstream at the local production end. The whole diagram fits the Met Office operations and FSSSI is the Met Office site-specific forecasting system using a one-dimensional add-on model. Field modification is the attempt to correct data streams high up in the chain.

This value added chain is important and quantifying how much value is added at the various points in the chain will be important in management decision making, or where to prioritize resources and role of forecaster in the future, etc.

APPENDIX J

AUTOMATED "SCRIBE" VS. FORECASTER ACCURACY





APPENDIX K

FROM THE ANNUAL REPORT OF THE NEW ZEALAND METSERVICE

KEY PERFORMANCE INDICATORS

for the year ended 30 June 2001

POD: Probability of Detection measures the proportion of forecast events against actual events.

FAR: False Alarm Ratio measures the proportion of forecasts where the actual event did not reach the warning criteria.

	Statement of Corporate Intent Target	Actual 2001	Actual 2000
Net Surplus attributable to Shareholders	$2,681,000	$3,711,000	$3,665,000
Net Surplus attributable to Shareholders : Average S/H Funds*	36.5%	58.8%	66.0%
EBIT : Total Tangible Assets	34.8%	45.0%	47.7%
Current Ratio*	1.01:1	1.18:1	1.21:1
Equity Ratio*	63.1%	54.1%	48.8%
Net Surplus attributable to Shareholders : Total Sales	11.5%	15.6%	15.7%
Accounting Value of Crown's Investment	$7,479,000	$8,426,000	$5,815,000
Probability of Detection (POD)	**Minimum**		
Heavy Rain	75%	88%	82%
Heavy Snow	75%	86%	87%
Severe Gales	75%	75%	85%
False Alarm Ratio (FAR)	**Maximum**		
Heavy Rain	40%	19%	29%
Heavy Snow	40%	32%	50%
Severe Gales	40%	28%	30%

Quality Certification

We retained full ISO 9001 recertification and are happy to record that the auditors found us fully compliant. After holding our initial Civil Aviation Rule Part 174 certification for 5 years, we have successfully received recertification with a high standard against the measurement criteria.

** Calculation of ratios for 2001 include dividends declared post balance date (see note 17) but not included in the Statement of Financial Position.*

Warning Criteria

MetService is required to issue warnings of widespread hazardous weather which may cause conditions that could threaten life or property on land. Warnings are issued to a variety of organisations and the media, in the form of Special Weather Bulletins.

Warnings of heavy rain are issued when:
rain is expected to exceed 50mm in six hours; or rain is expected to exceed 100mm in 24 hours.

Warnings of heavy snow are issued when:
snow is expected to affect areas below 1000m in the North Island; and snow is expected to affect areas below 500m in the South Island; and snow is expected to exceed 10cm in six hours, or 25cm in 24 hours.

Warnings of severe gales are issued when:
sustained winds are expected to exceed 47kt or gusts exceed 60kt, over land.

APPENDIX L

FT. SMITH AND VAN BUREN, ARKANSAS, TORNADO OF APRIL 21, 1996 NATURAL DISASTER SURVEY REPORT – EXECUTIVE SUMMARY AND TABLE OF CONTENTS-NWS-NOAA-USA

EXECUTIVE SUMMARY

On Sunday, April 21, 1996, a severe weather outbreak across the Southern Plains produced a number of supercell thunderstorms and tornadoes which developed in northwest Texas and southwest Oklahoma. This severe weather then tracked east northeast across much of south central and northeast Oklahoma and northwest Arkansas during the late afternoon and evening hours.

This report, while providing a general overview of the severe weather event, focuses on the Fort Smith metropolitan area of northwest Arkansas, where a strong tornado caused extensive property damage, two fatalities, and more than forty injuries.

The tornado touched down on the west side of downtown Fort Smith at 11:12 p.m. CDT on the evening of April 21, 1996. After causing extensive damage to a number of historic buildings in the downtown area, the tornado moved northeast through an industrial area and then into a residential area on the north side of Fort Smith. The tornado then crossed the Arkansas River and moved into a residential area on the west side of Van Buren, Arkansas, and continued moving northeast through a more sparsely populated area.

Two fatalities occurred in the residential area on the north side of Fort Smith. Two children died in frame houses heavily damaged by the tornado. Numerous injuries occurred in the residential areas of both Fort Smith and Van Buren, where the tornado substantially damaged approximately 1,800 homes. Two additional fatalities occurred in St. Paul, Madison County, Arkansas, approximately 50 miles northeast of Ft. Smith as the parent thunderstorm produced another tornado in that area almost one hour after the storm moved through Ft. Smith.

The tornado was estimated to be approximately one-half-mile wide with a path length of approximately seven miles. The F3 tornado, as defined by the Fujita Tornado Intensity Scale, was estimated to have wind speeds of nearly 200 mph. At this intensity, roofs and walls were torn off well-constructed houses, train cars were overturned, and automobiles were lifted off the ground.

The severe weather outbreak was forecast in advance. The National Weather Service (NWS) Storm Prediction Center (SPC) in Kansas City, Missouri, identified the potential for severe weather in the Oklahoma/Arkansas area nearly two days prior to the onset of the outbreak. Severe weather outlooks were issued by the NEXRAD Weather Service Forecast Office (NWSFO) in Tulsa earlier on the 21st based on information from the SPC. The SPC issued a Tornado Watch which included the Ft. Smith and St. Paul areas three hours prior to the tornado striking Ft. Smith and Van Buren.

A Severe Thunderstorm Warning, issued 16 minutes prior to the onset of the tornado, identified the potential for tornadoes. The warning specified *"Hail to the size of quarters and gusts to 70 mph can be expected in the warned area. A Tornado Watch is also in effect for the warned area. Remember, severe thunderstorms can and occasionally do produce tornadoes with little or no advance warning."* When a Tornado Warning was issued four minutes prior to the onset of the tornado, a power loss at the Ft. Smith Police Department caused a failure of the primary communications method with Ft. Smith officials, depriving them of critical input to their decision to sound the Civil Defense sirens. As a result, the sirens were not sounded. The same storm system then moved northeast and the Tulsa NWSFO issued a Tornado Warning for the St. Paul area 25 minutes before the tornado struck that community.

The Tulsa NWSFO detected and tracked the supercell thunderstorm which produced the Ft. Smith/Van Buren tornado using the Weather Surveillance Radar 1988 Doppler (WSR-88D) radar. In addition, the severe weather spotter network servicing the Ft. Smith area and immediately adjacent counties in Oklahoma provided timely reports to NWSFO Tulsa via amateur radio.

At issue is why a Severe Thunderstorm Warning was issued for a storm that had a known tornadic history. The NWS Disaster Survey Team found that the Tulsa warning team perceived that the storm, while still dangerous, was decreasing in tornadic potential and, therefore, issued a Severe Thunderstorm Warning. This perception was influenced by several factors:

1) The warning team relied most heavily on a velocity product which had provided clear definition of tornadic potential of the storm in its passage from McAlester through Stigler, Oklahoma, resulting in tornado warnings with 30 minute lead time. However, in the three six-minute radar observation cycles just prior to the tornado warning decision, this product provided ambiguous information which was most easily interpreted as a decrease in the intensity of the mesocyclone.
2) The warning team did not clarify tornado location inconsistencies between spotter reports and radar signatures.
3) The warning team put too much importance on the lack of damage reports from areas over which the storm passed in making their decision.

While the National Weather Service and the Ft. Smith community cannot alter the amount of destruction caused by a storm of this magnitude, working together as partners will minimize human casualties. The low loss of life in this storm may be attributed to a combination of factors. Preparedness activities conducted by the Ft. Smith and Tulsa NWS offices and their partners in the local government and private sector contributed to the public's knowledge of life-saving actions. Early, widespread media coverage of the weather outlook and the storm's potential threat to the Ft. Smith metropolitan area prompted individuals to seek safe shelter. The response of the local hospital and several senior citizen homes to the pending severe weather threat was

commendable. These facilities implemented their disaster action plans well in advance of the tornado's arrival in Ft. Smith.

There were numerous watches, forecasts and warnings issued throughout the afternoon and evening of the event. These products alerted citizens throughout eastern Oklahoma and western Arkansas to the potential of severe weather including the threat of tornadoes prior to the actual tornado warning for the Ft. Smith and Van Buren areas. This, coupled with the responsiveness of the media and a generally aware public, without doubt, saved lives. However, there were some important lessons learned from the Ft. Smith event which are applicable to the entire NWS. Greater emphasis on interpretation of a representative suite of available Doppler products, vigorous questioning and clarification of spotter information, and a reduced dependence on damage reports should enhance the warning decision making process.

TABLE OF CONTENTS

APPENDIX M

SEVERE WEATHER EVENT DATA DEFINITION

A report of severe weather is comprised of event data. In the table on the following page the event data is broken up into field names and corresponding values (columns 2 & 3). An example of each field value is included (column 4). The remaining columns (4-7) provide the specifications for the field values. The intent here is to capture the essence of the severe weather report and at the same time organize the information in such away as to facilitate the verification of the severe weather warning programme.

Category	*Field Name*	*Field Value(s)*	*Field Value Examples*	*Format*	*Units*	*Comment*
When	eventdata_date	Any valid date	2001-07-22	YYYY-MM-DD		Required
	eventdata_start_time	Any valid time	17:30	hh:mm	hour:minute 24 hour clock	Required
	eventdata_duration	Time period	00:30	hh:mm	hour:minute	Required
	eventdata_time_zone	UTC	UTC	alpha string		Required
Where	msc_region_abbrev	PYR PNR OR QR AR	OR	alpha string		Required
	public_fcst_rgn_name	Any valid public forecast region name	LONDON-MIDDLESEX-OXFORD	alphanumeric string		
	public_meso_scale_area_name	blank Any valid meso-scale area name	OXFORD COUNTY	alphanumeric string		
	eventdata_latitude	Any valid latitude	43:01 N	dd:mm N	degree:minute N	Required
	eventdata_longitude	Any valid longitude	81:09 W	dd:mm W	degree:minute W	Required
	eventdata_location	blank Any valid location	10 KM NW LONDON	alphanumeric string		
	public_fcst_rgn_split_name	blank Any valid public forecast region split name(s)	NORTHERN LONDON-MIDDLESEX-OXFORD	alphanumeric string		Required if split(s) exist
	public_meso_scale_area_split_name	blank Any valid meso-scale area split name(s)	SOURTHERN HALF COUNTY OXFORD	alphanumeric string		Required if split(s) exists
What	eventdata_type	Severe Thunderstorm Strong Winds Heavy Rainfall Heavy Snowfall Blizzard Freezing Rain Freezing Drizzle Blowing Snow Snowsquall Wind Chill Les Suetes Winds Frost	Severe Thunderstorm	alpha string		Required

Category	Field Name	Field Value(s)	Field Value Examples	Format	Units	Comment
	eventdata_tornado	blank Tornado	Tornado	alpha sting		
	eventdata_fujita_scale	blank F0 F1 F2 F3 F4 F5	F1	F{numeric}		
	eventdata_tstm_wind	blank number km/h [E]	110 km/h	alphanumeric string	km/h	
	eventdata_hail_size	blank number mm hail [E]	20 mm hail E	alphanumeric string	millimetres	
	eventdata_hail_depth	blank number mm hail depth [E]	35 mm hail depth E	alphanumeric string	millimetres	
	eventdata_rainrate	blank number mm of rain in number hrs [E]	50 mm of rain in 2 hrs	alphanumeric string	millimetres & hour	Short term
	eventdata_rain_total	blank number mm of rain in number hrs [E]	150 mm of rain in 24 hrs	alphanumeric string	millimetres	Long term
	eventdata_snow_total	blank number cm of snow in number hrs [E]	18 cm of snow in 24 hrs E	alphanumeric string	centimeters & hours	Long term
	eventdata_wind_steady	blank number km/h [for more that number hrs] [E]	65 km/h for more than 2 hrs	alphanumeric string	kilometers/hour & [hours]	
	eventdata_wind_gust	blank number km/h [for more than number hrs] [E]	95 km/h E	alphanumeric string	kilometers/hour & [hours]	
	eventdata_visibility	blank number km in sn/sg/bs/f/bd [for more than number hrs] [E]	0.5 km in bs for more than 6 hrs E	alphanumeric string	kilometers & [hours]	sn…snow sg…snow grain bs…blowing snow f…fog bd…blowing dust
	eventdata_windchill	blank number C [for more than number hrs] [E]	-45 C for more than 10 hrs E	alphanumeric string	C & [hours]	
	eventdata_freezing_precip	blank zr/zl for more than number hrs [E]	zr for more than 3 hrs E	alphanumeric string	hours	zr…freezing rain zl…freezing drizzle
	eventdata_freezing_precip_accum	blank number mm ice accretion [E]	8 mm ice accretion E	alphanumeric string	millimetres	

Category	*Field Name*	*Field Value(s)*	*Field Value Examples*	*Format*	*Units*	*Comment*
	eventdata_gen_comments	blank text	 Barn damage trees down	alphanumeric string		
	eventdata_damage	Wind Hail Flooding Lightning Freezing Precipitation	Wind	alpha string		
Report	eventdata_contact_source	EC employee Newspaper Police Public Media CANWARN Weather Watcher Climate Observation Other	CANWARN	alpha string		
	eventdata_contact_name	blank name	Joe Soaker	alpha string		
	eventdata_contact_ communicate	blank email: address voice: # fax: #	email:joe.soaker@ sympatico.ca voice:444-333-5555 fax:444-222-1111	alphanumeric string		
	eventdata_report_filed_date	blank Any valid date	2001-07-25	YYYY-MM-DD		
	eventdata_report_filed_time	blank Any valid time	13:30	hh:mm	hour:minute 24 hour clock	
	eventdata_qc	blank vetted	vetted	alpha string		blank means report is not vetted
	eventdata_recorded_by	blank name	Ted Thunderhead	alpha string		

Note: 1) “blank” option means the field value can be empty
2) […] indicates this part of the field value is optional
3) [E] means estimated and optional