Climatological Bulletin

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Canadian Meteorological and Oceanographic Society

La Société Canadienne de Météorologie et d' Océanographie

Information for Contributors and Subscribers

As a publication of the Canadian Meteorological and Oceanographic Society, the CLIMATOLOGICAL BULLETIN provides a medium of information on climatology. The Editorial Board gives special encouragement to the submission of manuscripts on applied climatology (e.g., agriculture, commerce, energy, environment, fisheries, forestry, health, recreation, transportation, and water resources), climatic change and variability, climate impact studies, climate model applications (including physical climatology), and regional studies (including ocean areas).

Authors may submit their manuscripts to "Articles", "Research Notes" or "News and Comments". This should be indicated in the cover letter accompanying the manuscript. Articles and Notes are independently reviewed by at least two anonymous referees. News or comments are reviewed by the Editor in consultation with the Editorial Board. Manuscripts are accepted in either English or French. An abstract (in both English and French) is required for Articles and Notes.

Contributors should submit manuscripts to Stewart J. Cohen, Editor, CLIMATOLOGICAL BULLETIN, Canadian Climate Centre, 4905 Dufferin St., Downsview, Ontario, M3H 5T4. All manuscripts should be typed double spaced on one side of good quality white paper, 28 cm × 21.5 cm, or its nearest equivalent. The abstract, list of references, tables, and a list of figure captions should be typed double spaced on separate sheets. Comments (including book reviews and opinions) and news items should not exceed 1500 words. Furnish an original and three copies if possible, in the order listed below.

TITLE PAGE should include the full names of author(s), and professional affiliation(s).
The ABSTRACT should be less than 250 words, and typed on a separate page.
The TEXT of longer contributions should be typed double spaced on numbered pages, and divided into sections, each with a separate heading and numbered consecutively. The section heading should be typed on a separate line.
ACKNOWLEDGEMENTS are typed on a separate sheet immediately following the text.
If FOOTNOTES are required, they should be typed, double spaced, on a separate sheet under the heading "Notes" at the end of the text.
REFERENCES should be arranged alphabetically by senior author's last name. The text citation should consist of name(s) of the author(s) and the year of publication, for example Jones (1975) or (Jones, 1975). When there are two or more cited publications by the same author in the same year, distinguishing letters a, b, etc., should be added to the year. A reference to "in press" implies that the paper has been accepted for publication. Titles of periodicals should be given in full.
FIGURE LEGENDS must be provided for each figure, and should be typed together, double spaced, on a separate sheet.
ILLUSTRATIONS should be numbered sequentially. Original drawings, lettering, and symbols should be large enough so that after reduction, the smallest characters will be at least 1.5 mm high.
Each TABLE should be numbered sequentially. Type all tables double spaced on separate sheets.

Authors should use the International System of units, but may show other units in parentheses. Authors should provide instructions in the margin for any special type required (Greek letters, capitals, bold face, etc.).

Page charges are not levied against the author. Authors of research articles will receive 10 reprints. Notes authors will receive 2 reprints.

Correspondence regarding Society affairs, membership, Institutional subscriptions and back issues of the journal should be directed to the Corresponding Secretary, Canadian Meteorological and Oceanographic Society, Suite 805, 151 Slater Street, Ottawa, Ontario, K1P 5H3. Telephone (613) 237-3392.

Renseignements pour les collaborateurs et les abonnés

Publication de la Société canadienne de météorologie et d'océanographie, le Bulletin climatologique offre un moyen d'information sur la climatologie. Le comité de rédaction encourage en particulier la soumission de manuscrits sur la climatologie appliquée (comme l'agriculture, le commerce, l'énergie, l'environnement, la pêcherie, la sylviculture, la santé, les loisirs, les transports, et les ressources en eau), les changements et la variabilité du climat, la prospective climatologique, les applications des modèles du climat (inclus la climatologie physique), et les études régional (inclus les océans).

Les auteurs peuvent choisir de soumettre leurs manuscrits aux "Articles", "Notes de Recherches", ou "Nouvelles et Commentaires". Ils doivent l'indiquer sur la lettre d'accompagnement du manuscrit. Les articles de recherche et les "Notes" sont indépendamment soumis à l'examen d'au moins deux appréciateurs anonymes. Le rédacteur en chef examine les "Nouvelles et Commentaires" conjointement avec le comité de rédaction. On accepte les articles soit en français, soit en anglais. Il faut envoyer un résumé, de préférence en français et en anglais.

Les collaborateurs sont priés de soumettre leurs manuscrits à Stewart J. Cohen, rédacteur en chef, Centre climatologique canadien, 4905 rue Dufferin, Downsview, Ontario, Canada M3H 5T4. Il faut dactylographier tous les manuscrits à double interligne, sur un côté d'un papier blanc de bonne qualité, de 28 sur 21,5 cm ou des dimensions les plus rapprochées. Il faut dactylographier à double interligne, sur des feuilles à part, le résumé, la liste des références, les tableaux et la liste des légendes. Les commentaires, les critiques, les opinions et les informations ne doivent pas dépasser 1 500 mots. Fournir l'original et, si possible, trois copies, selon la disposition suivante:

LA PAGE DE TITRE doit comprendre: nom, prénoms des auteurs, ainsi que les affiliations professionnelles.

LE RÉSUMÉ, dactylographié sur une page à part, ne doit pas compter plus de 250 mots.

LE TEXTE. Il faut taper à double interligne, sur des pages numérotées, le texte des articles plus longs et le diviser en sections, chacune dotée d'une en-tête à part et numérotée dans l'ordre. Il faut dactylographier l'en-tête de section sur une ligne à part.

LES REMERCIEMENTS doivent être dactylographiés sur une page à part, après le texte.

LES NOTES DE BAS DE PAGE doivent être dactylographiées à double interligne, sur une feuille à part, au-dessous de l'en-tête "Notes", à la fin du texte.

LES RÉFÉRENCES doivent être disposées dans l'ordre alphabétique, d'après le nom de l'auteur principal. Les citations doivent comprendre le ou les noms du ou des auteurs et l'année de publication, comme Jones (1975) ou (Jones, 1975). So l'on cite deux ou plusieurs publications du même auteur pendant la même année, il faut ajouter à l'année des lettres qui permettent de les différencier, comme a, b, etc. La mention "à l'impression" implique qu'on a accepté de publier la communication. Il faut indiquer les titres des périodiques en entier.

LES LÉGENDES: elles sont requises pour chaque figure. On dactylographiera ces légendes ensemble, à double interligne, sur une feuille à part.

LES ILLUSTRATIONS doivent être numérotées dans l'ordre. L'original des dessins, des caractères et des symboles doit être assez grand pour que, après réduction, le caractère le plus petit mesure au moins 1,5 mm de haut.

LES TABLEAUX doivent être numérotés dans l'ordre. La dactylographie pour tous les tableaux doit être à double interligne sur des feuilles à part.

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On ne fait pas payer de pages à l'auteur. L'auteur d'un article de recherche reçoit dix tirés à part et les auteurs des notes deux.

La correspondance concernant les activités de la Société, les souscriptions des membres et des institutions et les numéros déjà parus, devrait être adressée au Secrétaire-correspondant, Société canadienne de météorologie et d'océanographie, Suite n° 805, 151 rue Slater, Ottawa (ONT.) K1P 5H3. Téléphone: (613)-237-3392.

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Foreword

This issue marks the debut of the new Editorial Board of the Climatological Bulletin. Its members are listed below the Table of Contents on the first page. The interim Board, which had been assisting me during the 1982-84 transition from McGill University to CMOS, has been disbanded. My sincerest thanks go to Ben Garnier, Gordon McKay, Dave Phillips, John Powell, Wayne Rouse, and Marie Sanderson for helping to keep the Bulletin in operation.

The new Board's inaugural meeting was held on December 3, 1984. Among the issues considered at this meeting was editorial policy. The statement on policy has been more precisely defined, and appears in the first paragraph of Information for Contributors and Subscribers on the front inside cover, with the French version on the back inside cover. Our purpose is to provide a medium of information in climatology, while remaining complimentary in scope to Atmosphere-Ocean, the Society's other research publication. The Board accepted the view that articles describing climate as a physical system are appropriate for Atmosphere-Ocean. The Bulletin will review articles that consider climate issues as a physical system with biological, economic, social, or other physical connections, in continental or oceanic environments. This includes applied climatology, climate change, climate impacts, model applications, and regional studies. We recognize the interdisciplinary nature of this work, and we encourage submissions from practitioners in disciplines outside of the atmospheric sciences.

The formal review process will now be applied to research notes as well as articles. The Bulletin will continue to publish comments, news, and overviews which do not require formal review by independent referees. These items will be examined by the Editor in consultation with the Board.

Finally, a word about the volume numbering system. From 1967 to 1982, when McGill University was the publisher, each individual issue was numbered consecutively, 1-32. Beginning in 1983, volume numbers were used to indicate the year since the Bulletin was founded, hence Volume 17, No. 1 was the April 1983 issue. Pre-1983 issues should be referred to by Number (e.g. No. 30), while those published from April 1983 onward should be referred to as Volume and Number (e.g. Vol. 19, No. 1, or Vol. 19 (1)). A listing of all articles appearing in Numbers 1-31 was published in Number 32, the October 1982 issue.

Stewart J. Cohen

Weather extremes in Alberta: 1880 to 1960*

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[Original manuscript received 1 June 1984; in revised form 5 October 1984]

The impact of past weather extremes on rural residents of central and southern Alberta is measured by the frequency of reports of specific events in community histories. Descriptive information on the nature of the impact of important large-scale events is used to develop severe winter and drought indices from conventional temperature and precipitation data at weather stations with long-term records. The indices succeed in identifying the most extreme winters and droughts as recalled by rural residents who experienced them. In addition it is found that community histories contain useful data on dates, locations, and impacts of small-scale weather extremes. Some of the pitfalls associated with this type of documentary sources are identified and discussed.

L'impact des conditions météorologiques extrêmes du passé sur les habitants ruraux du centre et du sud de l'Alberta se mesure par la fréquence des récits des événements spéciaux contenus dans l'histoire des communautés. Des informations, décrivants la nature de l'impact d'importants événements à grande échelle, sont utilisées pour établir des indices d'hivers sévères ainsi que de sécheresses, en se servant des données conventionnelles de température et de précipitation des stations météorologiques qui ont des annales à longue durée. Ces indices arrivent à identifier les hivers et les sécheresses les plus extrêmes comme s'en souviennent les populations rurales qui les ont éprouvés. En plus, on trouve que les histoires communautaires contiennent des informations utiles sur la date, le lieu et l'impact des types de temps extrêmes même à petite échelle. Dans ce qui suit, nous identifions et discutons des piéges que ce genre de sources documentaires pourraient nous tendre.

1. INTRODUCTION

In the past twenty years, especially following Canada's Centennial Year, new Alberta community histories have appeared in large numbers each year resulting in coverage of most settled districts in the province. Almost all of these

*Presented at the 8th Annual Workshop of the Alberta Climatological Association, Edmonton, Alberta, 23 February 1984.

books include individual family recollections which, in turn, often include historical records of the impact of weather and climate on life, property, and activities on all scales from farms and hamlets up to regions. Remembered events include hail, summer frosts, blizzards, dry years, floods, ice storms, severe winters, dust storms, chinooks, tornadoes, and other local weather peculiarities which attracted attention because of rarity, beauty, or drama. The written records complement and supplement the numerical statistics from sparsely-distributed conventional weather stations but many questions arise concerning their reliability and use.

Historical climatology has been in limited use for many decades but only recently, following an upswing of interest in climatic change and the impact of climate on man, has the subject received wider attention. Some of the many pitfalls such as personal and cultural bias and the lack of contemporaneity, propinquity, and fidelity of communication, as well as the potential value of documentary sources, have been described by Ingram, et al. (1981), Lamb (1982), and Landsberg (1980). The documentary sources used here satisfy some but not all of the most important requirements for reliability. In particular, the accounts were written by persons who were present at the time and place of the weather event. However, with the exception of those based on diaries or local newspaper reports, the accounts were derived from memory and such accounts are subject to possible errors of exaggeration or dating errors. It is interesting to note that contemporary accounts, which are available in archives of local newspapers for many of the events considered here, often failed at the time to assess the total impact and severity of events such as droughts and severe winters which involved cumulative effects over months and years. The perspective of time is needed to judge severity in a relative sense. Furthermore, in early years newspaper accounts sometimes minimized the magnitude and impact of weather events in Alberta because each community was competing strenuously for new settlers.

Most previous users of documentary sources have been concerned with deriving weather and climate information for times and places where conventional climatological measurements were not available. In the present study, however, documentary sources are used (a) to identify weather events that escaped conventional measurement because of their small scales and (b) to attempt to relate the human impact of weather events of recent times on a rural population in one fairly homogeneous region to conventional climatological measurements. The work is incomplete and this report is best described as a progress report.

2. DATA COVERAGE

The basic data were derived from 142 community histories representing about 40 percent of the surveyed area south of township 61 (latitude 54°17′N) in Alberta. On average each history covers about 6 townships (92 km²). The largest gaps in spatial coverage occurred in Improvement District 1, centred near Medicine Hat, and Improvement District 14, which includes the Edson and Hinton districts. All weather events identified by specific years were logged. Some errors in dates are to be expected for local events of small impact. However, such errors can be dealt with statistically in large samples. The fact that attempts were made to associate specific dates with specific events adds conviction to the significance of those events.

In preparing frequency distributions, each event was counted only once per history book even though it may have been noted by many residents. Therefore, high frequencies resulted either from large impact areas from a single event or from frequent similar small-scale events in the same year within central and southern Alberta. The frequency distributions are believed to be most representative of the period from 1910, when massive rural settlement began, to the mid-1960s when significant numbers of the histories were published. The procedure of counting only one event of a specific type per book should have reduced bias caused by changing rural population densities. This is supported by the results for relatively frequent events such as severe hailstorms.

3. RESULTS

3.1 *Severe Winters*

The frequency distribution of reports of severe winters is shown in Figure 1. It is clear from this figure that the winters of 1906-7 and 1919-20 were outstanding for their severity. These, together with the winter of 1935-36, were mentioned most frequently in central Alberta, while the winter of 1886-87 was mentioned only in southwestern Alberta. The absence of date scattering in the neighbourhood of 1907 and 1920 is quite remarkable and demonstrates that these were events of major impact.

Mean winter temperatures (December, January, and February) at Edmonton are shown in Figure 2 for comparison with Figure 1. Edmonton was selected as representative of central Alberta. However, the results are insensitive to this choice because mean winter temperatures at Edmonton are strongly correlated ($r > 0.9$) with those at other weather stations with long-term records such as Medicine Hat and Calgary. Evidently, mean winter temperature data at Edmonton show little correspondence with the reports of severe winters shown in Figure 1. The winters of 1886-87 and 1935-36 were cold but not appreciably colder than those of 1949-50 and 1968-69. Furthermore, the winters of 1906-07 and 1919-20, which were outstanding according to community history reports, were not identified as unusual by mid-winter temperature data.

Many written descriptions of these severe winters are available in the local histories and it can be deduced from these that they were characterized by great length and by deep persistent snow cover. It is reasonable to

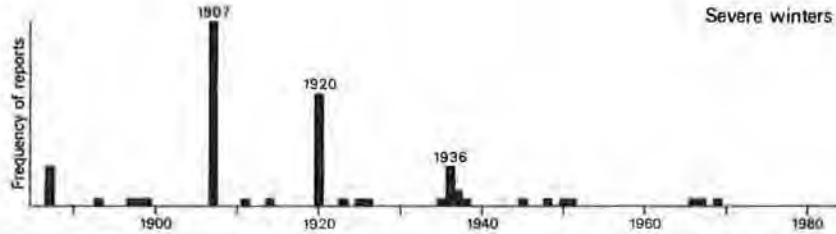

FIGURE 1. Frequency distribution of community history reports of severe winters in central and southern Alberta.

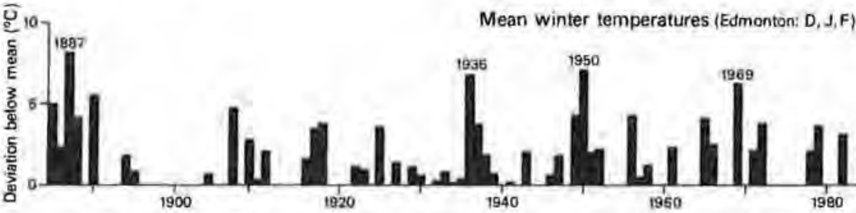

FIGURE 2. Winter temperatures at Edmonton expressed as deviations below the long-term mean.

assume that these characteristics had a greater impact on rural residents than extreme mid-winter temperatures. For both winters (1906-07 and 1919-20) there were many reports of winter snowbanks that persisted until early July. Indeed, for 1907 there were two reports of remnants of sheltered winter snowbanks that persisted until next season's snow (in deep ravines or valleys in the Islay and Gadsby districts of east central Alberta) — observations that seem incredible in the light of experience in recent winters in central Alberta.

On the basis of community history descriptions, a "severe winter" index was devised by assigning equal weights to early snowfall amount (October and November), low mean temperatures from October to March, heavy total snowfall, and low spring temperatures (April and May). The dimensionless annual severe winter index w ($-1 \leq W \leq 1$) shown in Figure 3 was computed from:

$$W = \frac{1}{4} \sum_{i=1}^{4} \frac{x_i - \bar{x}_i}{R_i} \qquad (1)$$

where x_1 = total snowfall (September to May)
x_2 = early snowfall (October and November)
x_3 = mean temperature (October to March)
x_4 = mean temperature (April and May)

and where $\bar{x}_i$ and R_i represent the mean value and range, respectively, for each variable for the period of record at Edmonton (1883-1983). Ranges were computed separately for positive and negative deviations from the means and appropriate sign adjustments were made so that large positive values of W were favoured by low temperatures and heavy snowfall. The variables x_2 and x_4 serve to identify early and late winters, respectively, in central Alberta. There is no assurance that the same indicators are valid for southern Alberta.

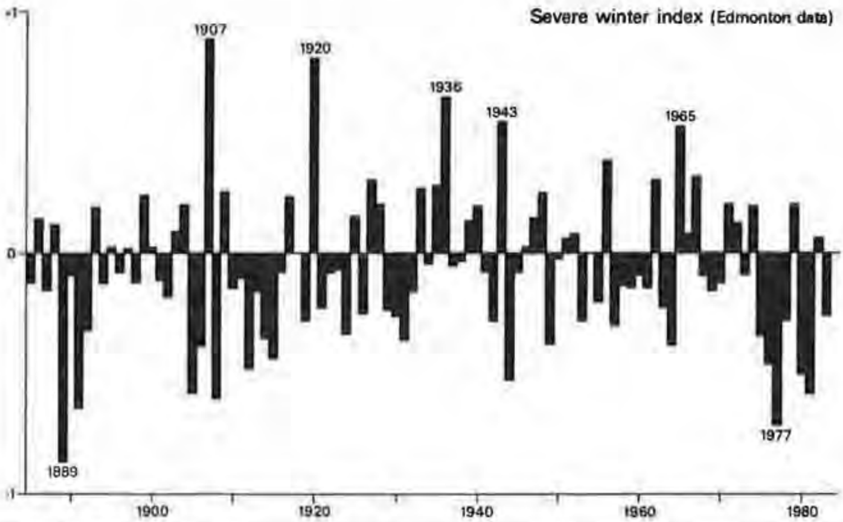

FIGURE 3. Severe winter index W derived from Edmonton temperature and snowfall data.

The distribution of the index W shown in Figure 3 corresponds much more closely with the community history reports of Figure 1 in that the three worst winters identified by rural residents were identified also, in correct order, by the combination W of measured temperature and snowfall data at Edmonton. Winters corresponding to the index maxima in 1943 and 1965 were not remembered as outstanding by community history authors. This may represent a failure of the index or it may indicate that those winters fall below the threshold of severity needed for a special place in the memory of residents.

3.2 *Dry Years*

Dated reports of outstanding dry years, wet years, and dust storms are shown in Figure 4. With notable exceptions in 1910 and 1914, wet and dry years occurred in groups perhaps more appropriately identified as wet and dry spells. Dust storms were reported first in 1918, and, by increasing frequencies, appeared to show evidence of the cumulative effect of the dry spells of 1917-26 and 1929-38.

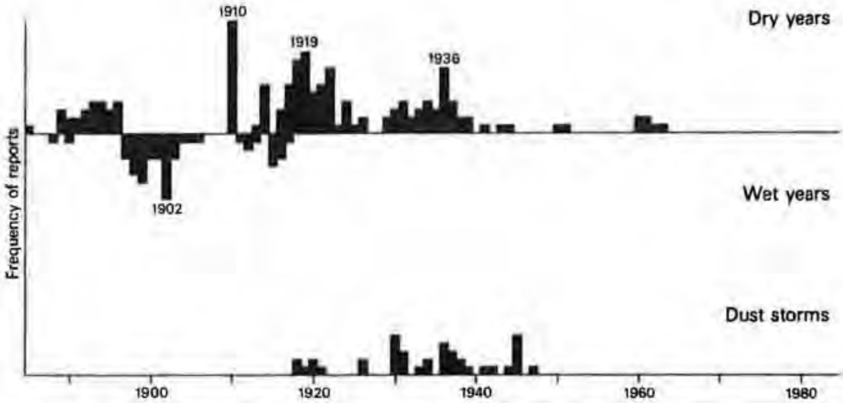

FIGURE 4. Frequency distribution of community history reports of dry years, wet years, and dust storms.

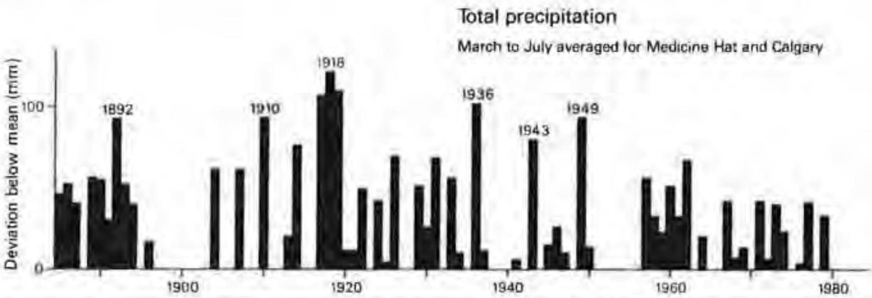

FIGURE 5. March to July total precipitation for Medicine Hat and Calgary expressed as deviations below the long-term mean.

Monthly precipitation, unlike monthly mean temperature, is not well correlated over large distances in Alberta. For that reason, and because almost all reports of dry years came from the community histories of southern Alberta, precipitation data from Medicine Hat and Calgary were combined for comparison with dry and wet year reports. The results for the period March to July in each year are shown in Figure 5. Here, as in the comparison of severe winter reports with winter temperatures, the correspondence between community history reports and climatic data is poor. In particular, the order of selection of the most important dry years differed in Figures 4 and 5. Furthermore, spring and early summer precipitation showed much less tendency for dry spells or groupings of dry years than the reports in Figure 4.

Descriptive comments in the community histories suggest that the dry years shown in Figure 4 were identified primarily on the basis of their impact on the crops and water supplies of individual farms. In an attempt to develop a "drought" index from measured temperature and precipitation data, it is instructive to consider the results of previous studies of the relationships between weather factors and crop yield, even though crop yield depends on many other variables such as soils, pests, diseases, and farming practices. The key parameter from the point of view of weather factors is soil moisture which rises and falls in response to precipitation, percolation, runoff, and evapotranspiration. The only available long-term measurements are those of screen air temperatures and gauge precipitation which are poor surrogates for soil moisture. Nevertheless, crop yield studies have shown significant correlations with spring and fall precipitation for selected crop sequences (Hopkins, 1936). Winter snowfall (November to March) on frozen ground did not contribute significantly to crop yield variations at Swift Current according to Barnes and Hopkins (1930). When fall precipitation is added to that of the following spring and summer, the results fail also to account for the ranking of dry years shown in Figure 4. All that remains to be tested with available data are the effects of temperature (Williams, 1962) and the cumulative influences of prior years.

A dimensionless drought index D ($-1 \leq D \leq 1$) was defined by

$$D = \frac{\sum_{i=0}^{n} a^i I_i}{\sum_{i=0}^{n} a^i} \qquad (2)$$

where I_0 is the drought index for the current year and $I_1, I_2, \dots I_n$ are corresponding indices for preceding years weighted by the numerical factors a^i ($a < 1$). The annual index I_i is given by

$$I_i = \frac{1}{2} \sum_{j=1}^{2} \frac{x_j - \bar{x}_j}{R_j} \qquad (3)$$

where x_1 = mean temperature (March to July), x_2 is total precipitation (August to October and March to July), and where $\bar{x}_j$ and R_j represent mean values and ranges, respectively, for each variable for the period of record (1886-1982).

Because of the factor a^i in (2), the contributions of preceding years decreases with increasing age and the sum can be terminated in practice at n = 3 to 5 for $a < 0.5$. The unknown weight a was estimated by linear correlation between D and the history book frequencies from Figure 4 for 1910-1960. The highest linear correlation was attained with $a = 0.4$. Because of the need for this step, it must be emphasized that the index D was not developed independently of the data with which it is to be compared, although it utilizes

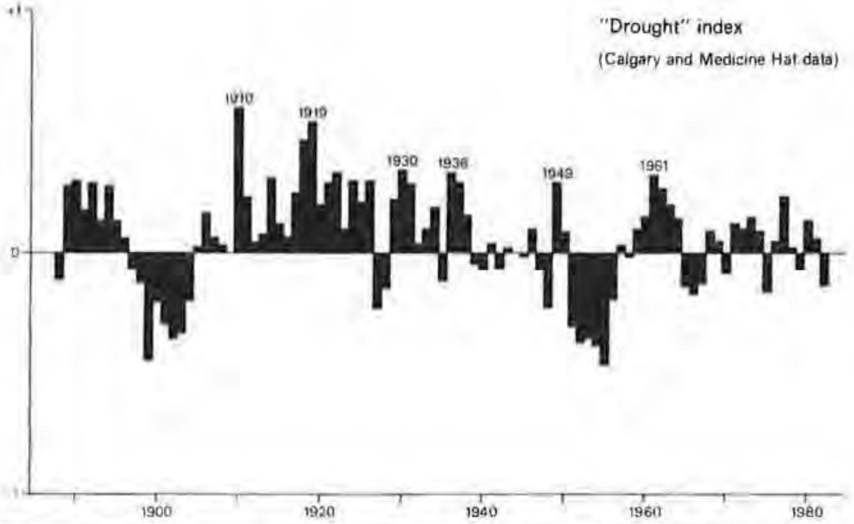

FIGURE 6. Drought index D derived from Medicine Hat and Calgary temperature and precipitation data.

TABLE 1. Correlation coefficients between community history reports of dry years and the drought index based on temperature and precipitation data from Calgary and Medicine Hat (1910-1960).

Variables		Correlation Coefficient
Mean temperature (x_1) only		0.47
Precipitation (x_2) only		0.67
Combined temperature and		
precipitation:	a = 0.00	0.71
	a = 0.02	0.75
(Figure 6)	a = 0.04	0.79
	a = 0.06	0.79

only measured temperature and precipitation data at Calgary and Medicine Hat.

The drought index D is shown in Figure 6. It accounts for about 65 percent of the variance of community history dry year reports shown in Figure 4. Correlation coefficients between reported dry year frequencies between 1910 and 1960 and various components of D are shown in Table 1.

The index D successfully identified 1910 and 1919 as the two driest years and it exhibited the desired tendency for grouping of dry and wet years. It is possible that D could be refined and improved by the addition of fall temperature data and by the addition of data from other weather stations. A more stable index could be devised by replacing R_j by the standard deviation. However, a more serious shortcoming is the lack of an independent data sample for test purposes. Most of the variance in reports of dry years was associated with very few years in which unusually high temperatures and low precipitation were combined in critical sequences of months. A much larger data sample is needed for testing the significance of correlations with such rare events.

It is unlikely that large negative values of the "drought" index D can be expected to correspond closely to community history reports of wet years. Descriptive comments in these books suggest that the primary impact of wet years resulted from unusually heavy summer precipitation (from July to August or September) which inhibited field work and crop ripening. An outstanding example occurred from 1899 to 1903 in central and southern Alberta (Roe, 1954). The years 1951-1956 with large negative D values were not remembered by the public as outstanding wet years.

In the following subsections frequency distributions of community history reports of several additional outstanding weather events are presented. The reports serve to identify the events but more work is needed to reconstruct the events and their impacts in detail.

3.3 *Killing Summer Frost*

The most remembered killing summer frost occurred between 21 and 25 July, 1918 from the Peace River region through central Alberta to Kamsack and Swift Current, Saskatchewan (Figure 7). Minimum temperatures of −5°C to −10°C were reported between Edmonton and Lloydminster. Crop and garden losses were enormous and the subsequent stench of rotting vegetation was recalled by many.

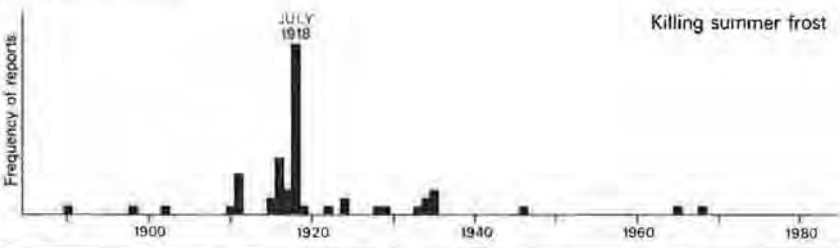

FIGURE 7. Frequency distribution of community history reports of killing summer frosts.

3.4 *Severe Hail and Destructive Winds*

The frequencies of reports of destructive hail, tornadoes, and other destructive winds are shown in Figure 8. With the exception of 1911 the time distribution of severe hailstorms is fairly uniform from 1910 to 1960 and shows no evidence of serious sampling bias in that period. The large number of reports in 1911 resulted mainly from one series of storms along a west-to-east strip from western Alberta through the Hand Hills and Buffalo Hills to Saskatchewan, and a second outbreak from Claresholm to Foremost. Both occurred near harvest and caused major crop devastation. Both were characterized by unusually

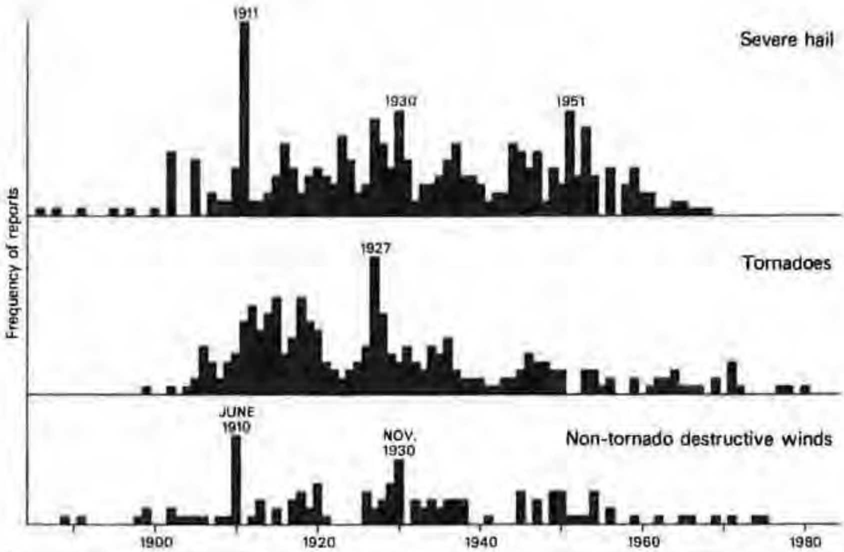

FIGURE 8 Frequency distributions of community history reports of severe hail storms, tornadoes, and non-tornado destructive winds.

destructive energy and large hail swaths.

The frequency distribution of tornadoes, in contrast to those of severe hail storms and non-tornadic winds, shows a systematic drop in frequencies with time. This is attributed to sampling bias caused by increasing average farm sizes and declining rural population density. With the exception of 1927 the highest frequencies occurred from 1910 to 1920 at the time of maximum rural population density in central and southern alberta. The tornadoes reported in community histories are those which caused building loss or damage and, therefore, the numbers reported depend directly on the number of occupied farmsteads.

Most of the 30 to 40 tornadoes reported in Alberta in 1927 occurred on July 8 and 9 — a two-day outbreak unique in the recorded history of the province. Five settlements including Vulcan and Rocky Mountain House were struck. More than 60 farmsteads suffered building losses ranging from grain bins to large barns and homes. Three persons lost their lives and several were injured.

Non-tornado destructive winds include cold fronts, chinooks, valley winds, and thunderstorm downdrafts. The cold front of November 22, 1930 was memorable for the severe building damage which occurred intermittently between Lac Ste Anne and the Saskatchewan border.

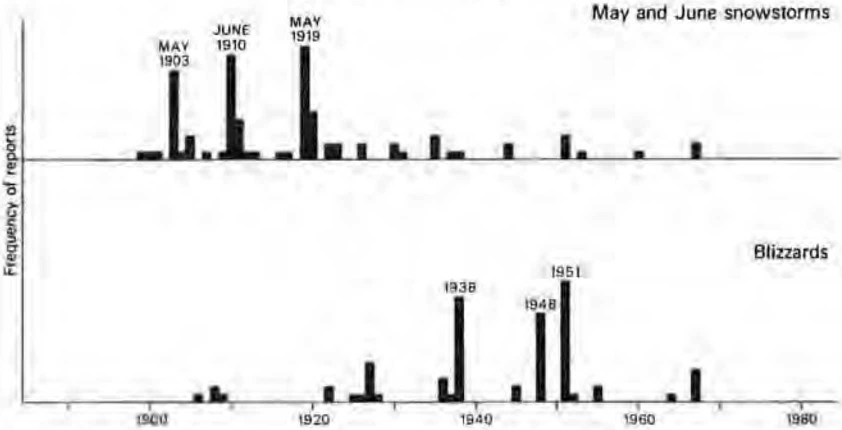

FIGURE 9. Frequency distributions of community history reports of May and June snowstorms and blizzards.

3.5 *Blizzards and Spring Snow Storms*

Memorable snow events identified by community history reports are shown in Figure 9. The late spring snow storms of 1903, 1910, and 1919 were appreciated by many for their contributions to soil moisture. Unfortunately, the May storms resulted also in major livestock losses. The storm of June 1910 was accompanied by strong winds with widespread, though minor, property damage. According to many residents, it provided the only significant summer precipitation in that extremely dry year.

The winter blizzards of 1938, 1948, and 1951 are remembered most for severe disruptions to transportation and communication and for huge 5 to 8 meter drifts that accumulated over rail lines, farmsteads, and other obstructions. The impact areas were well defined by the community histories and were typically in strips 500 km by 200 km. Further work is needed to relate the atmospheric structure of these storms to their areas of impact.

4. SUMMARY

Severe winter and drought indices, derived from combinations of temperature and precipitation data from three weather stations with long-term records in central and southern Alberta, were found to correlate reasonably well with the frequencies of community history book reports of these events, when some attention was paid to the nature of their impact on rural life, property, and activities.

The names attached, for the sake of brevity, to the indices are somewhat misleading and deserve comment. The so-called "severe winter" index was derived from data for the 8-month period from October to May, and it assumes large positive values only when low winter temperatures occur in combination with heavy autumn snowfall, low spring temperatures, and heavy total snowfall. The so-called "drought" index assumes large positive values only when low late spring and early summer precipitation occurs in combination with high spring and early summer temperatures, low preceding fall rain, and high index values in preceding years.

The two indices described in this paper were derived from conventional climatological data and compared with the written recollections of long-term rural residents of central and southern Alberta. The comparison, therefore, depends on the reliability of such recollections, and it is limited to annual values in a span of some decades in a particular region of western Canada. A serious deficiency is that the data sample was inadequate for independent testing. Even if the indices are valid measures of human impact in the period 1910-1960, it is not obvious that they can be extrapolated to present and future times because human perception of the impact of weather is relative and changing. Nevertheless, when one examines in some detail the characteristics of the "severe winters" of 1906-07 or 1919-20, for example, in terms of the length and severity of wintry conditions, it is hard to believe that if such conditions were repeated, they would not be considered extreme by both urban and rural residents of today despite major improvements in transportation, communication, shelter, and opportunities for recreation.

It is possible that an alternative index based on episodes of cold weather and heavy snowfalls may be a better measure of severe winters than that proposed here. Indeed, episodes such as outstanding blizzards, cold snaps, and snowstorms were identified in many local histories. However, it is unlikely that one or two such episodes would constitute a severe winter and, if many occur, the resulting episode averages of temperature and snowfall would be expected to correlate rather highly with seasonal averages so that the proposed index is at least an approximate measure of severe episode weather.

It is believed that the results of this study lend credibility to the use of community histories in identifying not only large-scale (regional) weather events of significant human impact, but also severe small-scale weather events for which weather station data are rarely available. Such data can open new doors to the past and, perhaps, through further study improve our understanding of present and future weather events.

A summary list of notable weather events based on high frequencies of community history reports is given in Table 2. It is interesting to note that only one event subsequent to 1950 was considered noteworthy by many people. This may reflect a real decline in impact or it may simply reflect the reluctance on the part of authors to include recent events in "history" books. The latter interpretation, however, is not supported by the fact that recent severe hailstorms (figure 8) were reported.

TABLE 2 Alberta weather extremes derived from community history reports 1880-1960.

Weather Event	Date
Severe winter	1906-07, 1919-20
Dry year (southern Alberta)	1910, 1919
Wet year	1902
Widespread hail damage	1911
Tornado outbreak	July 8, 9, 1927
Cold front winds	June 1, 2, 1910; November 22, 1930
Killing summer frost	July 21-25, 1918
Ice storm	April, 1932
Dust storm	June 2, 3, 1937; May 5, 1945
May snowstorm	1903, 1919
Winter blizzard	March 1938, March 1951

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News and Comments

WEATHER AND CLIMATE INFORMATION SERVICES:

A Viewpoint*

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INTRODUCTION

It's been said that people who work in the areas of weather and climate every day are well aware of the potential benefits of these types of information to agriculture. Others, including some leaders in agriculture and progressive farmers, also know the value of climate and weather information. But beyond these groups, the use of even presently available climate and weather data, research findings and information has an uneven and seemingly poor track record. Why?

If the potential value and cost-benefit ratios are so impressive, why hasn't the adoption and use of this information by farmers been quicker and more widespread? Why haven't those who make or influence decisions directed more resources to climate and weather programs for agriculture? Is more research needed? What are the present levels of knowledge and understanding by farmers of climate and weather? Do technology information transfer systems need to be improved to raise levels of knowledge and understanding and thus speed up the adoption process? Many more questions could be raised or situations cited that point to problems and gaps in the present climate and weather information delivery system for agriculture.

Let's take a look at a few of these and some suggestions for improvements.

*Presented as a viewpoint at the Expert Committee on Agrometeorology meeting, Ottawa, November 1 and 2, 1984.

CLIMATE OFTEN OVERLOOKED

Writing in the 1983 USDA Yearbook, Jim Newman and Bob Dale of Purdue University wrote:

> "As a natural resource, climate is often overlooked in agricultural planning. Some reasons for this lack of concern are:
> 1) Climate, as a composite of weather events over a period of time, is very abstract,
> 2) It is not fixed in time and space like other natural resource considerations, and
> 3) Climate is often viewed as given and uncontrollable, therefore nothing can be done anyway.
>
> These erroneous views produce a lack of appreciation for climate information and its use in decision making. This lack of use has in turn led to a lack of development in needed climatological data, their acquisition and analysis, in agricultural planning over the past several decades.
>
> As a result, much of the current soil erosion, flood damage and land management problems in agriculture are traceable, in part, to lack of appreciation and understanding of climate as a manageable resource. This omission of climate information needs to be corrected in future agricultural systems planning."

Relate these viewpoints to some situations in Canada.

One quickly thinks of the extensive efforts directed to soil and land use classification and even soil erosion compared with the lack of information in comparable detail of climate and weather above the soil.

Decision makers who decide on where available resources are to go for programs and projects in agriculture often view climate and weather data and information as inputs that are readily available from the federal weather services.

And farmers, generally speaking, live with the changing climate and weather conditions of the seasons. They don't get too excited yet about using complicated mathematical equations and probabilities in management decision making.

AUDIENCES

In the agricultural system, everyone uses climate and weather data and information of one kind or another. But the range and levels of data and information needs varies widely from those who require real-time to those who need only historical information. Some work with data at the micro scale level while others use meso, macro or combinations of all the scales.

In its technical report "Requirements and Availability of Agrometeorological Data in Support of Agriculture", The Expert Committee on Agrometeorology has documented data requirements of the agricultural industry in Canada. Others have conducted surveys on the use made of weather information, delivery systems and, to some extent, user needs.

What we seem to lack, though, is in-depth studies on present user levels of knowledge and understanding of climate and weather in such areas as terminology, concepts, myths and beliefs. It's only with this basic information, which describes fully where your audiences are at now, that we can build educational programs and technology transfer delivery systems in weather and climate that will have a true purpose, and begin to adequately bring about desired changes and the more rapid adoption of new improved practices on the farm.

While the results of such studies can be aggregated to provide an overview for some planning at the national level, they need to be done provincially and preferably within definable areas in a province. Too often when we design programs such as for weather – something that has an effect on everyone – we think of a single farm audience. There is no such thing. Rather, there are many farm audiences made up of individuals with either widely varied or quite similar levels of knowledge and understanding, likes or dislikes, and felt or unfelt needs or wants.

PUBLICATIONS, A/V AIDS

Earlier this year I wrote to state climatologists and others in every state in the U.S.A. and asked them to send me reference copies of extension-type printed literature on weather and climate which their state had available to farmers. I also asked for the titles and sources of any films, slide-sets, videotapes, or exhibits on weather and climate that would be useful to show to farm audiences or could be used in agricultural colleges.

The mail brought a wide range of printed literature. Most of it consisted of research articles, reports, and state and regional climate summaries and analyses. There were very few extension-type pamphlets and booklets.

No one recommended the title and source of a good audio-visual.

A number of state climatologists wrote and expressed their concern for the lack of educational materials in their state.

Next, the 1984 Canadian Agricultural Publications Index was looked at to see what titles were currently available in both English and French. Of the titles listed only 11 or .3% are directly on the subject of climate and weather. By comparison there were 17 titles or .5% on the subject of maple syrup and 262 or 8.1% on soils.

While it was noticed that a few known titles had been overlooked, the comparison, nevertheless, shows a very serious lack of extension literature on weather and climate subjects.

Surveys in the U.S.A. show that many climate studies, especially those with large amounts of data, and documents on such subjects as probabilities of precipitation and distribution of temperatures that are intended for farmer's use, end up on the shelf collecting dust. The conclusion is that the treatment and format of the subject is too complex. Most farmers cannot understand what it is that is being provided.

A New York survey turned up the fact that for their state climate summaries and monthly publications, the largest fraction of users were federal and state agencies. The second largest group of users was extension agents. Actual farmer use was very low even though the material was intended to be of use to farmers as well as for other users. It came as some surprise that there was a similar pattern in other states.

The gap is obvious.

A wide range of new extension materials on weather and climate information, useful to the farmer, need to be produced. Some existing publications of data summaries, equations, and modeling programs should be rewritten to put them into understandable and usable formats.

DATA COLLECTION

The primary mission of the Atmospheric Environment Service (A.E.S.) is to protect lives and property. The secondary mission is to provide information that aids in economic development.

Real-time synoptic observations taken by A.E.S. provide the meteorological observations necessary to provide the general weather forecasting for each region throughout Canada. The volunteer observation network provides basic data needed for long term analyses.

However, the density of such observations and the kinds of data collected are insufficient in Canada to provide all the data for agricultural needs, as well as other climatological needs. With the emergence of new methodologies in such areas as insect and disease control, crop development, and irrigation, networks intended for meteorological forecasting purposes are just insufficient for climatological purposes in agriculture.

Experience has shown that climatological programs for agriculture require ready access to observations from the area in which the crop is grown. In at least a dozen states in the U.S.A., separate networks have been set up using automated or semi-automated data recording equipment to provide this information.

If agriculture is to have the data to deliver the information needed to improve farm production, then it will have to fill in the gaps in the present network by setting up and operating its own data collection and delivery system. Where volunteer observers are incorporated into the system, the trend is to have observers enter their data by touch-tone telephone or a key-pad hooked to the telephone directly into a central computer. These data are then immediately available to both the weather service and to the cooperating state extension services.

Automated weather data stations are normally set up in defined agricultural areas, again with the data accessed directly into a central computer. The data provide inputs to predictive biological models and for other uses. This information in the central computer can be accessed by telephone by the farmer through use of a personal computer or TV set that has been fitted with a special converter.

Access to existing data of the right kind, in usable formats and available where and when needed, are other problems with the present system that are barriers to making full use of existing data.

DELIVERY SYSTEMS

Knowledge and information are of little value until they are transferred to users and applied by them. The ultimate users are farmers, and they have to be the prime consideration in the development of any weather-based delivery programs. Further, in communicating information, one must consider their current information seeking habits and how quickly they will adopt different or new methods to receive and use information.

In the past, much of this transfer of ideas and information was made through face-to-face contact with the individual. Person-to-person is still the most effective single method to create change and the adoption of new improved practices. But with increased demand for services, and, to be cost-effective, coupled with the emergence of new high technology delivery methods, reassessments have to be made of how farmers want or would like to receive weather information. Which methods do they prefer? And if there is a cost, how much are they willing to pay? Should the service come from the private sector?

Videotex and personal computer systems, in somewhat limited use on farms today, are considered to be the forerunners of systems that will be commonplace on every viable farm of the future. Such systems are well-suited for rapid transfer and analysis of pest, crop, and weather information, provided the data input, problem solving models, mathematical formulae and other information are available selectively to meet the individual needs of each farmer. Further, the user must be able to understand and be able to apply the information. The system must be user-friendly.

While no one system will meet the needs of all farmers, it's likely that preference will be shown for personal computer-based information delivery systems that are available at a reasonable cost. Such a system requires an internal computer-based delivery system for data and information inputs, analyses and communication throughout various levels of the operating organization, as well as being readily available to the on-farm user.

The Nebraska Agnet system is an example of a successful computer-based information delivery system for farmers as well as others in the agricultural sector.

Since most applications of climate information are on a local or regional level, the delivery system must consider the key role of extension workers who are decentralized and deliver advice and services from a county office, an institution or a research station. All need to be linked for fast transmission of information from a central provincial computer facility and headquarters that generates the information for agricultural purposes.

RESEARCH

Agricultural producers are the ultimate adopters of the products and techniques of the researcher. Too often, the results of research do not get adopted because, in part, the researcher feels little or no responsibility toward interpreting or assisting others to interpret the results of his research into usable form. It's reasoned that this activity is the responsibility of others, usually those in extension activities.

Weather is the driver that controls almost everything in the biological sphere of agricultural production. Because of this fact, agrometeorologists and agroclimatologists need to be considered more than they have been in the past as members of the research team working together with other scientists, if advances are to be made in solving weather related problems.

What is needed is a more systematic, interdisciplinary approach where the agrometeorologists are much more involved together with the scientists and the agricultural specialists in research and research delivery activities.

ON-FARM DEMONSTRATIONS

Throughout its history, on-farm demonstration has been effectively used by extension services to get farmers to adopt new or improved practices. The goals of provincial farm weather committees are to have weather forecasts for farmers improved and to have more climate information made available. If we expect farmers to better utilize this information in their management decision-making, a strong ongoing educational program will be required that involves not only farmers, but also extension specialists and agribusiness.

On-farm demonstration would be a good starting point for such a program with the goal that every farmer maintain and operate his own weather station.

Seasonal rainfall and, to a limited extent, temperature recordings are now projects of a number of county soil and crop improvement projects and a few 4-H Clubs in Ontario. Usually the county office compiles the data into a monthly summary mailed back to each participant. But little use is made of the information except for a farmer to note how much less or more rainfall he received on his farm during the month compared with his neighbours.

What is needed is to develop the idea of on-farm weather recording stations into a comprehensive educational program complete with materials on weather instrument selection and use, through to record keeping and use of the information in decision-making.

One climatologist has predicted that in the foreseeable future, some progressive farmers will be purchasing and operating their own automatic weather data recording stations.

SUMMARY

Weather controls the development of almost everything biological that the farmer produces, and a farmer's activities on the farm are daily governed by the weather conditions. If weather and climate are so important to the farmer, why hasn't the farmer a greater appreciation of the value and made better use of this information in his decision-making?

There are some major impediments to the use of climate and weather information by farmers such as:

- Lack of good basic publications, Factsheets, etc.
- Few definitive studies on knowledge, understanding and needs of farmers on the subject.
- Non-use due to complexity and abstractness of available data and information relative to "how-to-do-it" production information.
- Non-existence or inaccessibility of some desired data.
- Unaware of the material that is available.
- Value of information perceived to be of little use or its utility has not been well demonstrated.
- Unsuitable delivery systems. Information not available when and where needed and at a reasonable cost.
- Fear or lack of understanding of the use of mathematical formulae, modeling, probability predictions, etc., in decision-making.

Some considerations that ought to be made to improve the weather and climate program are:

- Better facts about our audiences: levels of knowledge, understanding and needs.
- A comprehensive and continuous educational program that includes the use of a wide range of information and instructional materials that are practical and useful.
- Interdisciplinary research needs to involve agrometeorologists and agricultural specialists, and they need to be party to the planning and delivery of weather-sensitive programs such as integrated pest management.
- Present networks for meteorological forecasting are inadequate for agriculture's needs. Agriculture must supplement it with observation stations to obtain the critical data it needs.
- There is a need at the provincial or regional level for the mainte-

nance of an adequate system or systems for the collection, analysis, storage and dissemination of basic and applied data and information. Such a system can only be computer based.

- Systems are required that provide ready access to data and information by farmers of the kinds he needs. Computer technology is high in the development of any system, but other traditional methods should not be overlooked.
- One goal of a climate program should be to encourage every farmer to operate his own weather station and apply the data he collects, together with information from other sources, in his production management decisions.
- Programs and projects involving on-farm weather recording activities offer one of the better methods to speed up the adoption and use of weather information on the farm.
- Decision-makers responsible for allocating resources need to be made fully aware of the value to the economy of comprehensive weather and climate programs.

ESTIMATING CLIMATE IMPACTS ON FOOD PRODUCTION IN CLIMATE-SENSITIVE AREAS

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Very little is known, at present, about the effects that changes of climate can have on agricultural productivity. Still less is understood about the economic and social impacts of productivity changes on systems of local and regional agriculture. However, we have the opportunity to address these important problems, for although we are not yet in a position to forecast how the climate may change in the future, we *can* examine the probable consequences for a variety of possible future scenarios. This is the premise behind a two-year research project based at the International Institute for Applied Systems Analysis (IIASA) in Austria and partly sponsored by the United Nations Environment Programme (UNEP).

The project is part of the World Climate Impact Studies Programme which is administered by UNEP and focuses on the effects of long- and short-term climatic change. This, in turn, forms one of four components of the World Climate Programme. The other three, administered by the World Meteorological organization (WMO), are concerned with monitoring the climate, with atmospheric research, and with applications in weather forecasting and agricultural management, respectively.

The IIASA project is built around an in-house core team of only 3 scientists, coordinating a network of over 70 collaborators in 13 regions around the world. The overall research goals are first, to evaluate the impact of climatic change and variability on food grains and livestock production, and second, to assess appropriate policy responses to reduce the impacts of climate on agriculture. These goals have been pursued through case studies in three broad types of climate-sensitive regions:

High-latitude, cold regions – where consideration of CO_2-induced climatic change has been emphasized, partly because CO_2-induced warming is expected to be more pronounced at higher latitudes, and partly because in these more economically developed regions agriculture is less prone to impact from short-term climatic variability. Collaborative studies are in progress in Saskatchewan (Canada), Finland, Iceland, Japan, and in the Leningrad and Cherdyn regions (northern European USSR).

Semi-arid regions – where local agricultural systems may be vulnerable to the impacts of drought, and where present-day climatic variability is a major source of system disruption. Studies are being conducted in the wheat belt of southeastern Australia, northeast Brazil, central India, Kenya, and in the Stavropol and Saratov regions (southern European USSR).

High-altitude regions – where low temperatures caused by elevation add a further dimension to agricultural vulnerability. Two studies are in progress – one in northern Japan where elevation, combined with northerly latitude, closely affects the limit of rice cultivation; and one at 3000 meters on the dry *paramos* in Ecuador, where there is a high risk of both drought and killing frost.

One particular analytical method for evaluating climate impacts on agriculture has been demonstrated in the case study regions, involving a hierarchy of three types of models. Scenarios describing possible future climatic conditions can be constructed using outputs from *climate models* (e.g. atmospheric general circulation models) or data from instrumental climatic records. These are used as inputs to *agroclimatic models*, which indicate the levels of crop yield that can be expected given certain specified climatic conditions. The yield levels can then be converted to production figures and input to *economic models*, particularly farm simulations indicating changes in farm income, and regional input-output models tracing the effects of those changes on agricultural expenditures in other sectors of the economy.

Elements from all three tiers of the hierarchy are available only in a few case study regions. Elsewhere we can expect to model the impacts only with regard to changes in potential crop yield. However, we can still describe the other aspects qualitatively, and consider the probable implications for agricultural policy in the future. For this reason, each case study team includes experts on the various subsystems through which the effects of a climatic event can be expected to cascade (a climatologist, agronomist, farm economist and agricultural planner).

At the outset of the project, a pilot survey was conducted in selected "cold" regions to assess the possible impacts on agriculture and ecosystems of CO_2-induced climatic changes. Iceland and Alberta (Canada) were among the specific study areas in which experiments were performed. The results have been published as a 4-page short summary (Parry and Carter, 1984a), as a 42-page IIASA Summary Report (Parry and Carter, 1984b), and as a collection of papers in *Climatic Change* which is reprinted as an IIASA Research Report.[1] The results from the main project will be published in two volumes in 1986.[2]

Work in the high-latitude areas is now complete, and papers are currently being reviewed. As such, only an indication of the results will be given here, demonstrating the approach in one area.

For example, in Canada, G.D.V. Williams and K. Jones (Atmospheric Environment Service) and E.E. Wheaton (Saskatchewan Research Council) have reported that GCM estimates of the Saskatchewan climate with doubled concentrations of atmospheric CO_2 point to much warmer and more drought-prone conditions, with enhanced risk of soil erosion by wind. Yields of spring wheat, as simulated by an agroclimatic model operated by R.B. Stewart (Agriculture Canada), could be expected to decrease across the province by, on average, 25 percent relative to present day levels. Accounting for variations in yield changes from one soil type to another, and assuming the same area planted as today, this represents a decrease in total provincial spring wheat production of about 2.6 million metric tons – a significant quantity, considering that Saskatchewan produces one-eighth of the world's traded wheat.

Some indications as to the sort of adaptations that could mitigate these effects can be obtained from the farm simulations performed by R.A. Fautley of Canada's Prairie Farm Rehabilitation Administration (PFRA). For example, if farmers were to switch from spring to winter wheat cropping, warmer conditions could be exploited while avoiding much of the problem of increased moisture shortages in the summer. Production in a warmer climate would thus be maintained, farm incomes protected, and the prosperity of the agricultural sector (as simulated by a regional economic input-output model) assured.

Experiments in IIASA's 12 other cases study areas are also pointing to alternative sorts of agricultural adaptation required to establish systems of food production more resilient to climatic change. It is hoped that governments and agencies in these and in other countries will recognize the potential of the approach as a planning and decision-making tool.

NOTES

1. M.L. Parry, guest ed., *Climatic Change 7* (January 1985), reprinted as *the Sensitivity of Natural Ecosystems and Agriculture to Climatic Change*, IIASA Research Report RR-85-1 (Laxenburg, Austria: International Institute for Applied Systems Analysis, 1985). All 3 IIASA publications are available, free of charge, from Dr. M.L. Parry at IIASA.
2. M.L. Parry, T.R. Carter, and N.T. Konijn, eds., *Assessment of Climate Impacts on Agriculture*; Volume 1, *In High Latitude Regions*, and Volume 2, *In Semi-Arid Regions* (Dordrecht, the Netherlands: Reidel, to be published in 1986).

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WORKSHOP ON EVAPOTRANSPIRATION, IRRIGATION, AND PLANT MOISTURE STRESS IN AGRICULTURE AND FORESTRY

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A one day workshop on Evapotranspiration, Irrigation and Plant Moisture Stress in Agriculture and Forestry was held on October 2, 1984 at the Kortright Centre for Conservation in Kleinburg, Ontario. This workshop was cosponsored by the Ontario Ministry of Natural Resources, the Atmospheric Environment service and the Canadian Meteorological and Oceanographic Society Special Interest Group in Agricultural and Forest Meteorology. The objectives of the workshop were:

1) to determine the current state of evapotranspiration and irrigation studies in crop systems and of procedures employed for field research programs and operations, and
2) to provide guidance for the definition of areas needing further study.

In addition, the workshop was designed to provide the wide range of prospective attendees with exposure to the theories and instrumentation involved, as well as the application of these for the purpose of evapotranspiration modelling and monitoring, and irrigation scheduling.

The program was divided into three sessions: theory, demonstration, and application. The workshop provided a valuable forum for discussion during and following the scheduled presentations. A publication of proceedings is planned and should be available during the spring of 1985.

The early morning session was reserved for two theoretical presentations: one representing forestry, the other agriculture. D. Spittlehouse of the B.C. Forestry Service began the morning session with a presentation of evapotranspiration modelling in forestry. The presentation included a review of two forms of evapotranspiration models, combination or Penman-Monteith, and an energy soil limiting approach, along with results from field experiments.

K.M. King of the University of Guelph discussed the measurement and prediction of evapotranspiration for agriculture. Various types of instrumentation involved in studies of this nature were presented along with a discussion of methodologies for integrating the interactions between the plants, soils and the atmosphere to provide a realistic model of evapotranspiration.

Following the morning session, the Site for Atmospheric Experiments in Woodbridge and the Ontario Tree Improvement and forest Biomass Institute (OTIFBI) in Maple were visited. These field tours were designed to allow those involved to gain an appreciation for the instrumentation involved in evapotranspiration studies as well as see some of the application programs currently underway. At the Woodbridge site, a demonstration of the Campbell Scientific eddy correlation instrumentation was given by B. Tanner. This particular equipment was designed to be portable and easily erected by one person, yet it is capable of providing reliable and accurate data. A tour of the AES lysimeter facilities was also given. This lysimeter has been in operation since 1972 and is currently undergoing refurbishing and updating before being brought back into service for a new program. Participants were also given the opportunity to examine the climate station facilities at this site.

At the Maple site, OTIFBI staff presented reports on relevant activities currently underway at the Institute. Included in the presentations was a discussion on Methods for Estimating Irrigation Water Requirements in Forest Nurseries and Mini-rotations prepared by C.S. Papadopol. This paper describes some of the problems associated with irrigation scheduling in these two environments. A proposed approach which is currently undergoing testing is described as well as future needs and developments. D.C. MacIver gave a presentation on the different needs of forestry for evapotranspiration and irrigation along with approaches for servicing these needs. Long-term planning needs could be met using climate information presented in the form of climatograms which depicted the various aspects of the climate, including evapotranspiration and precipitation for individual sites. A proposed approach for meeting the irrigation and related needs in forestry was also put forward. A demonstration of a meteorological micrologger system and the forestry research it was supporting was also given during this portion of the field tour.

Following the luncheon, the applications session commenced with D.S. Munro's presentation (University of Toronto) on the Evapotranspiration and Hydrology in Deciduous-Cedar Stands, Beverly Swamp Ontario. His discussion centred on the results of experiments carried out on evaporation from the stands in the wetlands environment. The complexities of the linkage between the water table and evaporation were also described.

B. Tanner (Campbell Scientific) discussed a number of the meteorological assumptions involved in using the eddy correlation instrumentation and the limitations under which these assumptions are valid. Results obtained during a field program were presented.

Plant moisture stress in three seedlings was discussed by S.J. Colombo of the Ontario Ministry of Natural Resources. Using wilting point as a first estimate of critical plant moisture stress levels, he examined the variation of the resistance of nursery stock to plant moisture stress over the growing season. The results, based on greenhouse pot trials, related the tolerance of seedlings to levels of plant moisture stress in terms of observed damage caused to the level of plant moisture stress reached, and the wilting point.

C.S. Tan (Agriculture Canada) presented the results of a two-year study on the evaluation of two methods of scheduling irrigation for peaches and tomatoes. A simplified Priestly and Taylor evapotranspiration model together with crop factors was found to be capable of predicting irrigation water requirements of the crop.

R.E. Pitblado of Ridgetown Agricultural College discussed the application of a computer based soil water budget system using the procedures developed by Dr. Tan. The results of the first year's field trial in a tomato crop were presented.

The use of matric potential measured by portable tensiometers, to schedule irrigation in forest nurseries, was presented by V. Timmer of the University of Toronto. Included in this presentation was a discussion of the advantages and complexities involved in using these devices in nursery management.

B. Nicks of the Ontario Ministry of Natural Resources presented results of a preliminary experiment to examine the potential for delaying flowering in jack pine seed orchards. The design of the experiment, and the results and implications in terms of seed orchard management were discussed.

W. Rouse of McMaster University provided a summary of the day's activities in terms of the current status and future directions of the study of evapotranspiration, irrigation and plant moisture stress in agriculture and forestry. For agriculture, irrigation scheduling for high value commercial crops using simplified equilibrium/combination models and or soil moisture measurements appears to have a lot of promise. In forestry, practical prediction models of the energy soil limiting variety need to be calibrated for the major forest regions of Canada. Factors limiting this task include the incorporation of the biological factors and the poor forest climate data base.

WORKSHOP ON CLIMATE IMPACT ASSESSMENT IN THE GREAT LAKES BASIN: RESEARCH STRATEGIES

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The workshop was held February 8-9, 1985, at Seneca College, King City, Ontario. The following report is based on my own observations of the keynote lectures, and the deliberations of the socio-economic discussion group, one of five organized at the workshop. I was a member of that particular group. All five groups presented their recommendations at the final plenary session. Proceedings will be published as a monograph by the University of Toronto's Institute for Environmental Studies, which managed the workshop under the auspices of the Canadian Climate Program.

The workshop began on the morning of February 8, with H. Ferguson and R.E. Munn presenting opening remarks. H. Ferguson noted that the Canadian Climate Program has already provided funding to several universities for work on Prairie agriculture, Ontario agriculture, and the Great Lakes, and that more funds would (hopefully) be available over the next several years. R.E. Munn (Univ. of Toronto) spelled out the purposes of the workshop: to bring people up to date on background information and policy issues, to discuss research strategies on impact assessment of CO_2 warming, and to consider present and future data requirements, particularly climate information.

W. Riebsame (Univ. of Colorado) opened the first keynote session by listing various prevailing views of what climate is (a background environment, a natural hazard, a natural resource, etc.), and the main challenges facing climate impact researchers. These include scenario development of socio-economic systems, identification of sensitivities, separation of signal from noise, and linkage of three sets of models: climate change, physical/biological systems, and socio-economic systems. This requires inter-disciplinary approaches, presently done by loose networks, temporary teams, or permanent institutions. Possible research strategies include signal vs noise studies, particularly studies of marginal areas and extreme events (maximize the temporal climate signal) or case-control and core area studies (minimize the spatial climate noise). The Great Lakes Region represents a type of minimized-noise study because of the international border that splits the region. Here, the effects of different policy structures of Canada and the U.S. should become evident.

M. Parry (IIASA) discussed several problems associated with impact studies. One major problem is the mismatch of scales that exists between global climate models and impacts on local agriculture, commerce, etc. Another is the interpretation of climatic change. A climate model indicates changes in mean temperature and precipitation. A climatologist could infer changes in frequencies of extreme events. However, one might also view climatic change in terms of risk levels and resource opportunities. Reference was made to an upcoming issue of the journal *Climatic Change*,[1] which includes several articles on assessing impacts in economic, as well as biological terms.

The remaining keynote lectures were overviews of various aspects of the Great Lakes Region's natural and human systems. J. Knox (Toronto) discussed the present synoptic climatology of the region. He also pointed out that more work is needed to link GCM results to individual episodes and extremes that might be produced on a regional scale.

M. Sanderson (Univ. of Windsor) reviewed past and present lake levels and net basin supply estimates. There has been a strong correlation between precipitation and lake levels, but temperature can play a significant role. F. Quinn (NOAA, Michigan) pointed out that lake levels did not rise during the 1920-1958 warming, despite the relatively high precipitation that occurred in most years. Quinn also presented an estimate for Lake Erie of future runoff and net basin supply under a CO_2 doubling scenario. Assuming a 2°C increase in all months, with normal precipitation, lake evaporation would increase 12%, runoff would decline 25%, and overall net basin supply at Lake Erie would decline 30%. Ice cover would be reduced, with accompanying changes to the thermal structure of the lake, and seasonal cycles.

H.A. Regier (Univ. of Toronto) described the influence of air and water temperature on fish production, and the difficulties in separating the effects of climate change from other factors. He also provided copies of a manuscript on fisheries co-authored by Regier and several others, where various individual fish species were examined.

B. Smit (Univ. of Guelph) discussed possible impacts on agriculture, noting that these were not restricted to changes in yield alone. There might be changes in crop type, relocations of certain types, and losses of others. An additional factor is technology, both the development of new hybrids, and improvement in the soil base. Impacts are dependent not only on the nature of climate change (e.g. new frequencies of extremes, interannual variability, etc.), but also on government policies on food production, non-agricultural land uses, and economic conditions prevailing both within and outside the region. However, it should be possible to at least do a sensitivity study of various climatic change scenarios, without having a precise projection of climatic change, so that threshold levels can be established.

P.A. Timmerman (Univ. of Toronto) discussed several limitations to socio-economic impact studies, given the current lack of knowledge on how climate and society interact. Previous studies on extreme events may not help to explain climate-society relationships. There has been a tendency to expect too much from such studies, and to think about impacts only in a narrow sense. An additional problem is the "marketing" of climate impacts to politicians. We should not be frightened by the diversity of available models, but we must be able to translate results from one socio-economic sector to another. Such studies must also include risk modelling/assessments, which may indicate how the climate-society relationship can change with time. A good example is the influence of dams or crop insurance on people, inducing them to move into risk-prone areas to live or work. Physical impacts are being replaced by monetary impacts. Are economic signals drowning physical signals? How does this affect societal resilience and vulnerability to climatic change? Will our future expectations change in an extrapolative, adaptive, or rational (i.e. economically efficient) way? How will this affect political decision-making, which in the past has often ignored economic signals?

The final keynote lecture was given by S. Changnon (Illinois State Water Survey) on public policy in the Great Lakes. There are several important pieces of relevant legislation, particularly the 1909 Boundary Waters Treaty, which created the IJC, the 1972 and 1978 Water Quality Agreements, and the 1980 Memorandum of Intent on acid rain. However, many policies are unwritten, and have been developed in an ad-hoc manner, as a reaction to an immediate problem. As in the socio-economic area, numerous uncertainties prevail when examining the climate-policy interface. It is easy to delineate the important Great Lakes issues (water quality, acid rain, water quantity and future diversions), but it is more difficult to translate research results into policy. Impacts research must produce action options for policy-makers by stating the risks associated with all policy options, including the "no response" policy. The scientific data base, and prevailing opinions from the science community, are considered a "moving target" for policy makers. They perceive differences of opinion as a reason for delay. However, in the Great Lakes, there has been progress on several issues, including water quality and the diversions "threat", which have led to the drafting of a unified regional agenda, a "Charter", signed on February 11 by all eight states, Ontario, and Quebec, which addresses principals for management of Great Lakes resources.

After the evening banquet, we split into several groups, in order to produce specific recommendations on future research strategies. The socio-economics group was led by P. Timmerman and A. Grima (Univ. of Toronto). The Friday evening discussion mostly concerned the climate change scenarios. Could these be provided as a continuous time series for a wide range of variables? Or, wouldn't it be possible to do sensitivity studies on a range of scenarios without waiting for the perfect GCM (General Circulation Model) to produce a perfect projection? It was obvious that few people in the group knew any details about the prevailing climate change scenarios, since they were not discussed in the keynote lectures. As a result, a new group on climate change scenarios was formed on Saturday morning.

Other issues included the identification of individual socio-economic sectors that might be the most affected by climatic change. There may be certain points of vulnerability within each sector. Historical studies would be useful, as would a ranking of sensitive sectors by dollars, employment, etc. This information would help to provide the building blocks for research on future impacts.

The discussion continued on Saturday morning. Several people suggested the need to do "coefficient crunching", to link physical and socio-economic systems, to answer some "what if" questions (similar to scenario development) and to study the "risk surfaces" of various sectors. Because of the inter-disciplinary nature of the work, a regional network of researchers would have to be established.

In general, the discussion avoided site-specific issues, concentrating instead on the broader philosophical issues underlying the research problem. Wholistic frameworks for impact studies would have to be developed in the future, but the group did not want to consider any specific models during the workshop.

Final recommendations were provided by all groups on Saturday afternoon. The policy group listed a number of sectors that needed to be studied (e.g. transportation, hydropower, consumptive use, etc.), and recommended that the research be oriented towards policy issues. It has to answer the "so what" questions, be honest about knowledge limitations, give the total picture (region, nation, Canada-U.S.), tailor the products to the needs of policy makers, and show a consensus to the public. Visibility is important, which thereby requires lobbying of policy makers and key groups by "activists" from the research community. Water levels is seen as a key issue.

The scenarios group recommended that results from GCM's should be used as primary case examples, and that climate modellers should work on determining changes in various aspects of climate, other than monthly temperature and precipitation.

The socio-economic group recommended both sector-by-sector research and the development of integrative frameworks. The former would yield building blocks of thresholds, sensitivities, and vulnerabilities. Then, the latter could be pursued. Additional information would be needed on the rate of climatic change, and information transfer between researchers and policy makers. A research network should be established as soon as possible.

The biological and physical systems groups each listed requirements for more specific data on climatic change, particularly the rate of change of certain variables (e.g. winds, ice cover, length of seasons, radiation, etc.). More research would be needed to describe the impacts of changes in various climate parameters, as well as air and water pollution levels.

In summarizing the results of the workshop, K. Hare (Univ. of Toronto) suggested that the composition and roles of the Canadian Climate Planning Board and the Science Advisory Board be changed, so as to include economists and social scientists. The nature of climate impacts research necessitates a more active role for these disciplines.

Overall, I felt that the exercise was extremely useful. I learned a great deal about impacts research as a "discipline" in its own right, and hopefully, this workshop planted the seeds of a new network of Great Lakes impact researchers. Regular meetings are vital to the success of a research effort such as this, so that the total picture can be examined. The bottom line, of course, is that proper networking requires a central organ of communication (including a bulletin or newsletter), personal exchanges of views and information, and, because of the international border, the involvement of an agency with bilateral interests to assist in co-ordinating a region-wide research effort. The success of these efforts will depend on the availability of long-term funding.

NOTE

1. *Climatic change*, 7 (1).

ALBERTA CLIMATOLOGICAL ASSOCIATION ANNUAL MEETING

The Alberta Climatological Association Newsletter reports that the ninth annual meeting and workshop, originally scheduled for February 21, has been moved to June 4, 1985.

Workshop presentations are being sought in applied climatology. The presentations are not intended to be formal papers, but rather a useful and thought-provoking discussion of scientific and technical activities and/or concerns in this area. Deadline for abstracts was March 15, 1985. For further information, contact:

Alberta Climatological Association
c/o Serge Dupuis
4th Floor, North Petroleum Plaza
9945-108 Street
Edmonton, Alberta
T5K 2G6

L'ASSOCIATION DE CLIMATOLOGIE DU QUÉBEC

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L'Association de climatologie du Québec a été fondée le 29 octobre 1982 lors d'une assemblée générale de fondation à laquelle assistait une cinquantaine de personnes intéressées à la climatologie. Cette assemblée avait été convoquée par un groupe de travail formé en 1980.

Le principal objectif de l'Association est de promouvoir la présence et l'utilisation de la climatologie et des sciences connexes au Québec. A cette fin, l'ACLIQ veut regrouper toutes les personnes ou organismes qui s'intéressent à la climatologie.

La troisième assemblée générale annuelle de l'ACLIQ eut lieu le 19 octobre 1984. A cette occasion, l'Association eut l'immense privilège de recevoir comme conférencier invité Monsieur F.K. Hare qui a entretenu son auditoire sur les changements climatiques. Lors de la réunion, les personnes suivantes furent élues au Conseil d'administration: M. Ferland, président; F. Shériff, vice-président; P. Dubreuil, secrétaire; B. Félin, trésorière; R. Leduc, J. Litynski et A.M. Lamothe, directeurs.

En 1984, l'Association a publié deux numéros de la revue *LE CLIMAT* qui se veut un bulletin d'information sur les activités en climatologie. La revue contient aussi une rubrique destinée aux articles scientifiques originaux. Un répertoire d'activités et d'expertises en climatologie au Québec fut publié en 1983. Ce répertoire veut favoriser l'accès aux informations climatologiques et permettre d'identifier des individus ou organismes en mesure de répondre à des besoins d'études ou de données. Cette publication sera mise à jour en 1985.

Suite à des démarches de l'ACLIQ, l'Association canadienne-française pour l'avancement des sciences (ACFAS) met la climatologie au programme de ses congrès depuis 1984. Lors du congrès de 1984 tenu à l'Université Laval, 17 conférences furent au programme. De plus, un colloque fut organisé autour du thème des problèmes de l'enseignement de la climatologie et de la météorologie; cinq conférenciers invités y ont participé.

En 1985, l'ACLIQ organise de nouveau un programme de conférences lors du congrès de l'ACFAS qui se tiendra à Chicoutimi du 21 au 24 mai. Cette année, le colloque traitera de l'état de la recherche en climatologie. Les personnes intéressées à y participer sont les bienvenues.

Plusieurs groupes de travail sont présentement actifs au sein de l'ACLIQ (tourisme, marketing, journal, etc). Toutes les personnes désireuses de se joindre à l'un de ces groupes ou à devenir membre de l'ACLIQ ou désirant des informations supplémentaires peuvent contacter le secrétaire, monsieur Pierre Dubreuil, SEA, 100, boul. Alexis Nihon, 3ième étage, Ville St-Laurent, H4M 2N3, tél. 514-333-3020.

SNOW HYDROLOGY RESEARCH IN CENTRAL EUROPE

The Proceedings is now available from a Workshop on Snow Hydrologic Research in Central Europe, held in Hann.Munden, Fed. Rep. of Germany, from March 12 to 15, 1984. The Proceedings is published as "Mitteilungen DVWK Nr. 7" or report No. 7 of the German association for water resources and land improvement (DVWK). The cost of the Proceedings is DM 49.00, and it may be ordered from

DVWK
Gluckstrasse 2
D-5300, Bonn, FRG

About 60 scientists (10 countries) participated and 25 presentations were given ranging in subjects from physical properties and energy considerations of the snow cover to the processes and dynamics involved in the accumulation and melt of the snow cover, both in the open and under various forest conditions. One-third of the papers is in English, the remainder in German, each with an extended abstract in English. Included are two North American contributions: "Influence of Forest Cover and Forest Removal on Accumulation and Melting of Snow in an Eastern Canadian Catchment" by R.B.B. Dickison and D.A. Dougharty, and "Snow Hydrology Research in the USA and its Application to Watershed Management" by A.R. Eschner. The Proceedings is 650 pages in length.

SYMPOSIUM ON NATURAL AND MAN-MADE HAZARDS

The Tsunami Society is sponsoring the International Symposium on Natural and Man-Made Hazards, to be held August 3-9, 1986, in Rimouski and Quebec City, Quebec. The Université du Québec à Rimouski will host the meeting.

The objectives of the Symposium are to promote the advancement of the hazards sciences, including comparisons of various hazards, and reviews of the newest developments in a few selected fields. New directions for future research will also be discussed.

Among the wide range of topics to be included in the Symposium are tropical and extra-tropical cyclones, lightning, hail, snow, acid rain, nuclear winter, carbon dioxide effects, climatic changes, air pollution, flash floods, icing, avalanches, floods, droughts, desertification, and of course, tsunamis.

Authors are invited to submit extended abstracts to the Coordinator of the Symposium before October 31, 1985. For further information, contact:

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