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DEVELOPPEMENT D'UN PROCEDE NUMERIQUE POUR LE CALCUL AUTOMATIQUE DES PENTES ET DE LEUR INSOLATION

par

Michel Lecarpentier *

Depuis le venue de l'ordinateur et son utilisation de plus en plus courante, le développement de modèles mathématiques cherchant à caractériser la réalité, s'est fait de façon accrue. Différent modèles de calcul automatique du rayonnement solaire arrivant au sol on déjà été élaborés, notamment par A. Ohmura (1969).

Personnellement, nous avons voulu imbriquer un modèle numérique de la topographie dans le calcul de l'énergie solaire reçue par le relief. De plus, il a été possible de développer un procédé d'analyse pour déterminer la position et l'extension des ombres portées par le relief. Cependant à la différence des modèles précédents qui s'attachaient à calculer l'énergie reçue en un point sur une surface unitaire, nous avons voulu pousser plus loin en intégrant ces valeurs sur la surface réelle des pentes.

I. Le Calcul Numérique des Pentes

Partons du principe que par trois points non-alignés dans l'espace l'on peut faire passer un plan et un seul. Ensuite choisissons sur le terrain trois points (P_1, P_2, P_3) assez rapprochés les uns des autres et dont on connaît pour chacun les coordonnées x, y et z (x : lon-

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* Michel Lecarpentier est un candidat doctoral en climatologie à l'Université McGill. Cet article est un extrait de la thèse de maîtrise présentée par l'auteur à l'Ecole des Gradués de l'Université Laval.

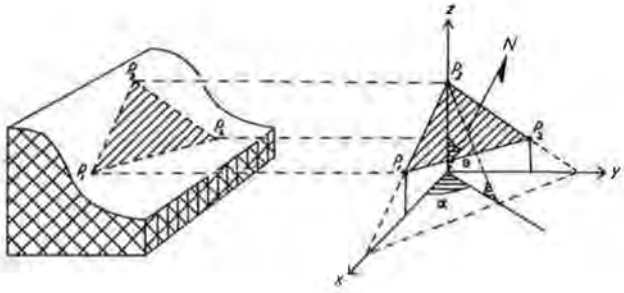

Fig. 1 La détermination des facettes triangulaires

gitude, y : latitude et z : altitude). Par ces trois points, l'on peut faire passer un plan qui caractérisera l'état moyen du terrain entre ceux-ci et duquel on pourra calculer la déclivité et l'orientation. De plus les trois points permettront de déterminer des facettes triangulaires dont la surface varièra en fonction de l'inclinaison de la pente (Fig. 1).

Pour un système de coordonnées fixes placé à l'origine, l'équation de la facette triangulaire devient:

$$\frac{z_3 - z_1}{z_3} X + \frac{z_3 - z_2}{z_3} Y + \frac{1}{z_3} Z = 1 \qquad (1)$$

où z_1, z_2 et z_3 sont les altitudes des points P_1, P_2, et P_3.

A partir de cette équation, il devient possible de déterminer la déclivité de la pente, qui est l'angle θ fait entre le plan de la facette et le plan horizontal. Le cosinus de cet angle est donné par l'équation:

$$\cos \theta = \frac{1}{\sqrt{(z_3 - z_1)^2 + (z_3 - z_2)^2 + 1}} \qquad (2)$$

A l'intérieur d'un quadrant, l'orientation (α') de la facette est donnée par l'angle entre projection de sa normale (n) sur le plan horizontal et un axe de référence (axe des X). L'orientation à l'intérieur du quadrant est donnée par α' et l'azimut de la pente est égal à α' + la position du quadrant. L'angle α' est obtenu par la relation:

$$\tan(\alpha') = \frac{z_3 - z_2}{z_3 - z_1} \tag{3}$$

D'autre part, la surface de la facette (S) est déterminée par l'équation:

$$S = \tfrac{1}{2} \sqrt{(z_3 - z_1)^2 + (z_3 - z_2)^2 + 1} \tag{4}$$

II. Le Rayonnement Solaire Direct et les Ombres Portées

L'intensité de la radiation arrivant sur une surface est fonction de l'angle 'i' entre le flux d'énergie et la normale de la surface réceptrice. D'après W. Kaempfert et A. Morgen (1952), le rapport trigonométrique entre la position du soleil dans le ciel et la position d'une pente est:

$$\cos i = \sin h \cdot \cos\theta + \cos h \cdot \sin\theta \cdot \cos(a - \alpha) \tag{5}$$

où 'i' est l'angle entre les rayons solaires et la normale à la pente, h et a sont l'hauteur sur l'horizon et l'azimut du soleil, et θ et α sont le déclivité et l'azimut de la pente.

Donc la valeur instantanée du rayonnement solaire direct reçu au sol sur une pente sera:

$$Q_i = Q \cdot \cos i \tag{6}$$

où Q est l'énergie solaire directe reçue au sol sur une surface prependiculaire aux rayons, et Q_1 est l'énergie solaire directe reçue au sol sur une surface quelconque.

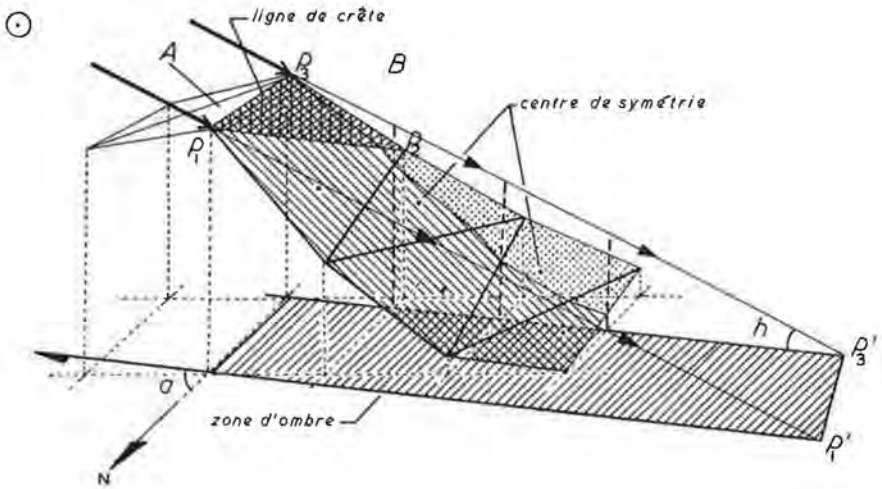

Fig. 2 La limite de l'ombre portée par rapport avec des facettes.

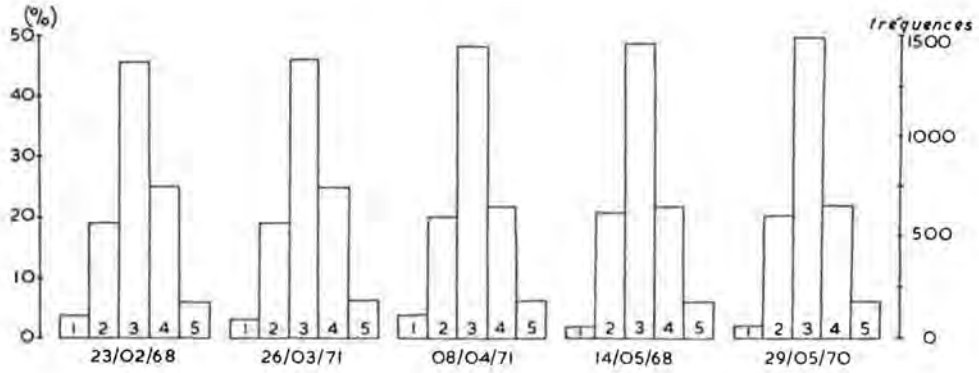

Fig. 3 Fréquences des valeurs pour chaque classe d'insolation.

Les valeurs d'énergie intégrées sur chaque facettes (Q_f) seront:

$$Q_f = Q_i \cdot S \tag{7}$$

Possédant un modèle numérique de la topographie, il parut avantageux de l'exploiter en faisant une analyse des ombres portées par le relief.

Pour trouver au sol la limite des ombres portées, il s'agit d'y faire la projection, selon les rayons solaires, des lignes de crêtes limitant sur le terrain les zones à l'ombre des zones éclairées. Avec l'équation (5), il est possible de déterminer la position du soleil par rapport à une facette. Supposons que nous sommes en présence de facettes attenantes A et B (Fig. 2), A faisant face aux rayons solaires et B étant en opposition. La limite, c'est-à-dire la ligne de crête engendrant l'ombre portée, passera par les points communs aux deux facettes et qui sont en même temps ceux les plus élevés de la facette à l'ombre (P_1 et P_3).

Si maintenant nous avons une suite de facettes dans l'axe des rayons solaires, l'on peut savoir si chacune d'elles est éclairée ou non, en faisant l'évaluation du cosinus 'i' sera inférieur à zero ($\cos i < 0$) alors celle-ci sera dans l'ombre. La première des facettes que l'on trouvera à l'ombre, marquera la position relative de la ligne de crête. Cette position pourra être précisée par les coordonnées des deux points les plus élevés (P_1 et P_3 dans l'exemple). Leur projection sur l'horizontale (P'_1 et P'_3) donne la limite de la zone d'ombre au sol, le plan d'ombre étant limité par les points $P_1\ P_3\ P'_3\ P'_1$.

Comme des facettes adjacentes peuvent être recoupées par la limite de l'ombre de façon à ce qu'elles soient en partie à l'ombre et en partie éclairées, il sembla pratique de caractériser chaque facette par son centre de symétrie et de ne considérer que la position de ce point par rapport aux limites de l'ombre. Si un centre de symétrie est au-dessus du plan d'ombre ou hors des limites latérales de l'ombre, la facette correspondante sera considérée comme éclairée et à l'inverse elle sera dans l'ombre.

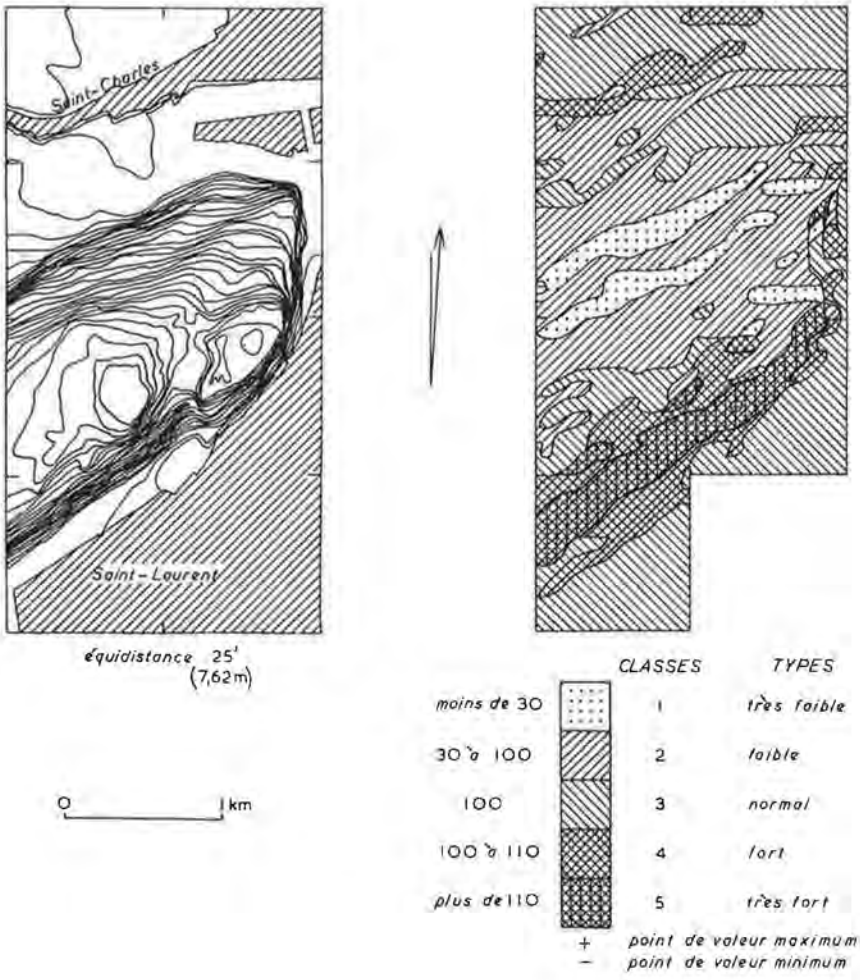

Fig. 4 La zone d'étude et le rayonnement soleil direct reçue au sol.
a) La topographie de la zone d'étude
b) L'insolation relative

III. Résultats des Calculs

A. Le rayonnement solaire direct sur la région de Québec

A partir de mesures de transparence de l'atmosphère faites dans la région de Québec par le professeur A. Hufty de l'Université Laval, une série de cinq journées allant de la fin février à la fin mai, a été sélectionnée pour calculer le rayonnement solaire direct. Les résultats ont été utilisées de manière qualitative en dressant une carte de l'exposition relative des diverses parties du terrain et de façon quantitative en faisant la sommation des valeurs énergétiques de divers sites, calculant pour chacun d'eux le taux d'accroissement sur la période de temps choisie.

De ces résultats de rayonnement solaire direct sur le terrain, il a été possible de tirer pour chaque journée, des cartes d'insolation relative. Celles-ci ont permis de voir que par rapport à une classe centrale d'insolation moyenne (insolation sur une surface horizontale), les autres classes se distribuaient généralement dans la même proportion autour de celle-ci. Au passage de l'hiver à l'été, les classes inférieures et supérieures tendent légèrement à se rapprocher de la classe centrale (Fig. 3). Cependant l'on peut, en considérant de façon globale les résultats, tirer une carte des insolations relatives (Fig. 4). Cette démarche peut être justifier par le fait que le coefficient de corrélation entre la distribution des valeurs du 23/02/68 et du 29/05/70 est de 0,992.

D'autre part, l'on a fait la comparaison des valeurs d'énergie intégrées pour divers sites. En exemple nous présentons celle fait entre la partie la moins ensoleillée du terrain, soit les falaises NNW de la plateforme de Québec, et la partie recevant le plus d'ensoleillement, soit les falaises SE. La figure 5 nous donne les taux d'augmentation de l'énergie solaire directe reçue sur les deux sites. Ce taux d'augmentation est le rapport des diverses valeurs quotidiennes sur la valeur quotidienne minimale. Les taux ont été calculeés du 23 février au 29 mai et passent de 1 à 3,35 pour les falaises NNW, alors que pour les falaises SE la variation n'est que de 1 à 2,02.

Ayant inclus, dans le calcul du rayonnement solaire direct, la coupure due aux ombres portées, on a pu noter que pendant la période d'étude, le maximum de perte n'était que de l'ordre de 2% (le 23/02/68). Ces pertes ont été relevées au pied des falaises NNW qui ont une

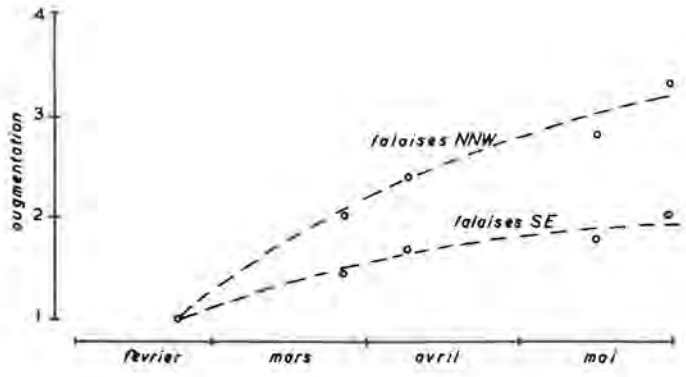

Fig. 5 L'augmentation de l'énergie solaire directe reçue par les falaises NNW et les falaises SE.

dénivellation de 30 à 50 mètres.

B. Les cartes de durée des ombres

Ces cartes englobent à la fois les parties du terrain qui sont à l'ombre par leur position propre et celles qui sont dans une zone d'ombre portée.(Fig. 6). Il est à noter, sur la carte du solstice d'hiver, que les plus longues durées d'ombre se répartissent en croissant autour des falaises NNW, N et E, ainsi que sur la plateforme, le long d'une ligne de plus fortes pentes. Cette ligne est d'ailleurs parallèle aux falaises NNW. Les falaises SE ne sont presque pas dans l'ombre cette journée-là. A l'équinoxe, les ombres gagnent sur les falaises SE alors que leur intensité diminue du côté N et NNW; qu'il s'agissent des falaises ou du rebord de la plateforme. Enfin au solstice d'été, les ombres ont pratiquement dégagées les flancs N et NNW de la plateforme pour s'étendre du côté SE, notamment lors de la période précédant le coucher du soleil. De ces trois cartes il ressort une constante qui est une durée prolongée des ombres sur le flanc E de la plateforme et les parties en contrebas.

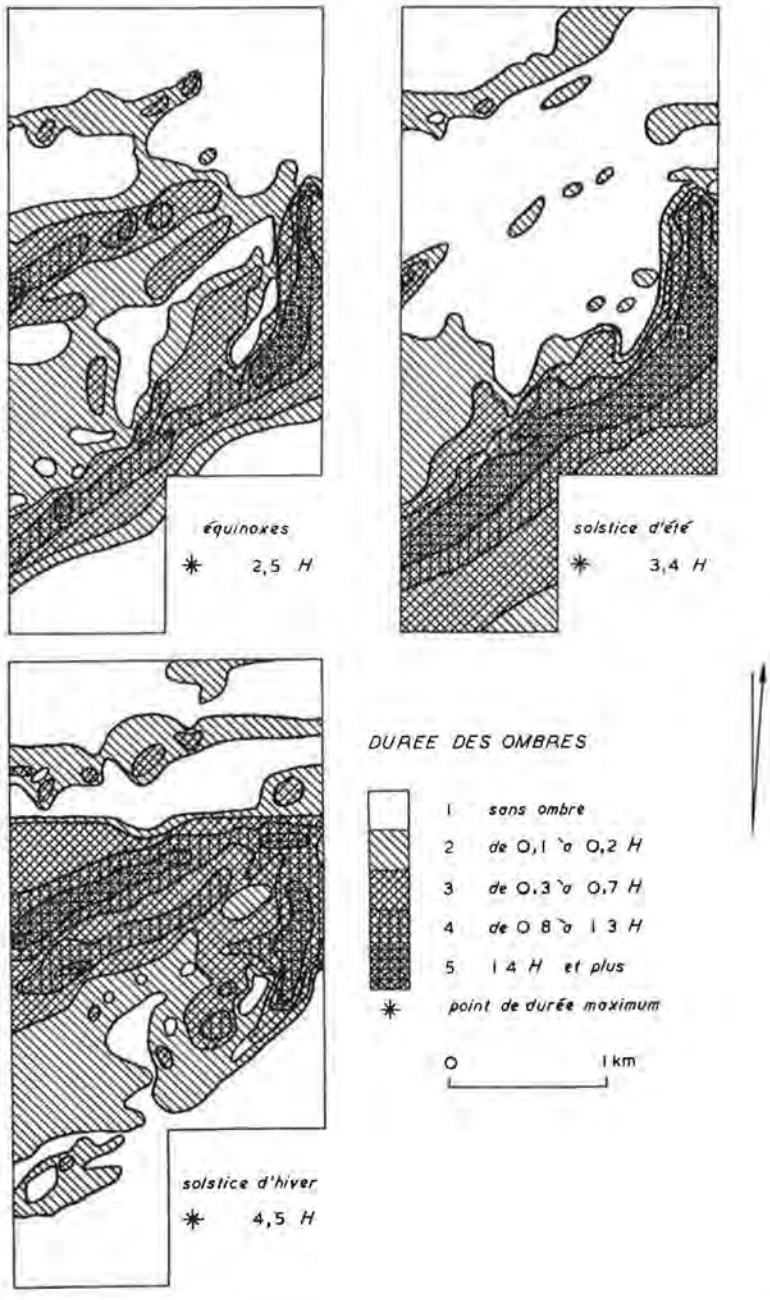

Fig. 6 La durée des ombres dans la zone d'étude aux équinoxes et aux solstices.

Que l'on considère les valeurs d'énergie integrées ou le calcul des ombres portées, ces résultats ont un caractère nouveau. Il semble donc nécessaire de poursuivre la recherche dans cette voie pour définir de quelle façon l'on pourrait utiliser les valeurs intégrées de rayonnement dans des étude comme un bilan théorique de rayonnement qui se font jusqu'à présent de manière ponctuelle. D'autre part il paraît également nécessaire, pour déterminer dans quelle mesure on doit faire un calcul des ombres portées, d'étudier les interrelations pouvant exister entre l'accentuation du relief et l'échelle de travail puisque cette dernière joue directement sur la précision des résultats.

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PUBLIC RESPONSE TO WEATHER TERMINOLOGY IN THE KITCHENER-WATERLOO AREA

by

G. R. McBoyle*

Monitoring of the public's understanding of weather forecast terminology has existed since the '40's, but doubts have been expressed whether in fact the accuracy of the public's understanding of forecast terms has kept abreast of the increasing accuracy of actual forecasts. This study purports to evaluate, for the Kitchener-Waterloo region, the lay perception of aspects of weather forecast terminology.

Several published studies exist as reference material. For example, one of the earliest was done by H. Landsberg in 1940 (Landsberg, 1940), when he assessed groups of students (20-83 per group) at Pennsylvania State College as to their ability to marry up his proposed terminology with existing weather conditions. The results, he found, provided good agreement. The general tenor of the article was an appeal for more accuracy and specificity in forecasting, on the grounds that "terms should be unmistakable", and therefore accurate for a local area in order to maintain a degree of specifity.

In 1949 the controller of the Canadian Meteorological Service had a questionnaire circulated at the University of Toronto "to determine the public understanding of weather terms" (Canadian Meteorological Service, 1949), but in fact the sample used was of 200 second and third year psychology students. No interpretation of results was made nor reference to correct answers, but in general conclusions that may be elicited are:
a) that the priority of information desired has a ranking of 1 - tempera-

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ture; 2 - precipitation; 3 - sky aspect; 4 - wind, and that b) qualitative terms, e.g., strong for wind, are preferable to a numerical designation alone.

Some years later, between 1950-1952, J. Sherrod and H. Neuberger undertook to test several thousands of students at Pennsylvania State University by questionnaire (Sherrod and Neuberger, 1958). Their results suggested a poor understanding of meteorological terms and that any further "education of the public to a more complex terminology is impossible". They recommend, therefore, more simplified terminology to aid public understanding and avoid public disenchantment with the service. This, then, is in direct conflict with Landsberg's proposals of 1940.

Assessing the British weather forecasting scene, B.C.V. Oddie published an article in 1964 in which he rationalizes the system in use in the B.B.C., pointing out that the lay listener should be able to understand the forecast, hence technical terms should be avoided or qualified by useful adjectives (Oddie, 1964). In order to overcome the problem to which Landsberg referred, that of "accuracy over large areas", a broad forecast for the whole U.K. is given, then a detailed report for the regional area. Noting the difficulties with some terms, e.g., the dropped terms "fair" and "showers", and the change in the use of "warm" and "cool" to relate to the previous day's weather, rather than seasonal conditions, he concludes that no major changes were required in B.B.C. forecasting, whose goals should be, according to Oddie, that forecasts are "generally understood" and "pleasant to listen to".

Comparison with the 1949 University of Toronto results was the purpose behind W.J. Maunder's study, published in 1969, of the responses of 400 geography students at the University of Victoria to a similar weather terminology questionnaire (Maunder, 1969). With the understandable digression of precipitation exhibiting a higher priority in Victoria than in Toronto and a greater sensitivity to winds in Victoria, his results were very similar.

Additional questions probed the money value placed by the students on a currect weather forecast, (62% thought it worth 10¢ and over), and their estimate of the degree of accuracy of forecasts (55% thought 75% or more forecasts were correct). In conclusion Mauder states that more study into the nature of public understanding of weather forecasts, and their requirement for them, "may in fact be just as worthwhile in the long run as more accurate forecasting, however desirable the latter is."

In 1970 the Canadian Meteorological Service (now the Atmospheric Environment Service) published the results of a survey done at the Montreal Weather Office, of persons who 'phoned the Office specifically for weather information (Aber, Lacoste, and Dussault, 1970). The intention was to determine whether the 300 people interviewed were aware of recent changes in the forecasting format. Most (80.7%) were unaware of changes; though those who were approved of them. The most interesting points are that: most (59.5%) were men; the forecast was required mostly for personal (64.7%) rather than business (35.3%) purposes; 51% of the male callers fell into professional - technical and managerial positions of occupation, with service and recreation next in prominence; over 60% of the women callers were in clerical positions (part of their job?); and that radio tended to be used more frequently for personal use, with telephone most frequent for business use.

One of the largest undertakings in assessing public attitudes to weather terms was carried out in December, 1971 by R.H. Rogell of the National Weather Service, N.O.A.A., Detroit when he arranged for a questionnaire probing the general understanding of "confusing" terms, weather "probabilities", and local climate, in the Detroit Free Press (Rogell, 1972).

The local climate of Detroit did not seem to be well known. And, despite some terms being well understood viz. "freezing rain", and "tornado watch", for the most part some distinction existed between official terminology and lay understanding of it. "Partly sunny" was found to be a confusing term, "wind chill" was not clearly understood, and "frost warnings" tended to be muddled with "freezing conditions".

But considerable agreement seemed to exist among the public with regard to the question of "chance" in probabilities, albeit at odds with the official usage of the national Weather Service. The suggestion is made that "slight chance" be used for the 20-30% probability; "chance" for the 30-40% probability, and "likely" for 50% (and over, presumably). Ironically the probability of precipitation was conceived more in respect of an area than for a particular point. Use of "snow showers" to express "brief, fairly intense periods of snow flurry activity producing little accumulation"(Rogell, p.131) is suggested.

If this small selection of publications is indicative, one is

TABLE ONE

Complete Listing of All Terms used by Radio, Television and Newspaper in the K-W Area from January 22 to February 5, 1973

Precipitation	Temperature	Sky Condition	Wind Condition
* snow flurries	* mild	* cloudy	* calm
* rain showers	* cool	* sunny	* light
* freezing rain	* cold	* overcast	* moderate
* chance of	* very cold	* clear	* gusts
* occasional	* cooler	* mostly	windy
* likely	unseasonable	* partly	variable
rain		mainly	
snow		partial	
drizzle		increasing	
few		considerable	
periods of		some periods	
wet			
light			

* words marked with an asterisk were used in the questionnaire. These are terms used over the 2 week span at least 5 times. Most of the terms with an asterisk were used daily.

forced to conclude that, whatever the sample bias, "lay" understanding of official terminology is confused, often to the point of being incorrect. In the latter cast, forecasts received will at best be unsatisfactory and at worst have no credibility. The following is an attempt to assess the situation for the Kitchener-Waterloo (K-W) region in Ontario, avoiding any bias in the sample by use of a random stratified procedure of the adult population.

The study conducted by the writer in Kitchener-Waterloo attempted to gauge understanding of official meteorological terms and of additional terms employed by local radio stations CHYM (K-W), CKKW (K-W) and CFCA (K-W); by local newspaper, the Kitchener-Waterloo Record, and by the local TV station CKCO TV (K-W area). For meteorological office terms reference was made to the operational manual of the Atmospheric Environment Service (AES)(Dept. of Transport, Meteorological Branch, 1966), MANPUB, to obtain terms with definite meteorological meaning and those with no set meaning, but believed to be generally understood.

Table One shows a list of all terms obtained by content analyses of the mass media categorized according to precipitation, temperature, sky condition and wind conditions. To limit the length of the questionnaire,

a selection of terms used by the media had to be made, and these are indicated by an asterisk in Table One. They were selected on the basis of having been used over the two week study period (January 22 - February 5, 1973) at least five times. Most of the terms with an asterisk were used daily.

Some of the terms used in the questionnaire (see Appendix) have a precise meteorological meaning, others have not. Examples of terms with a definite meteorological meaning are questions 11, 13, 17, 21 and 24. Questions 6, 7, 9, 12, 19 and 23 comprise terms which are given for use in MANPUB but with no set meaning, since they are regarded as being generally understood. In the case of question 26 the term "cooler temperatures" is defined by the Regional Director for use by forecasters in local areas. The terms employed in questions 5, 10, 14 and 20 are those used before January 31, 1972, and are regulated by District Offices. Finally, some of the terms used are not to be found in MANPUB. Question 18 is such an example, while the term "partly cloudy" employed in question 15 is, according to MANPUB, to be prohibited in usage.

Evaluation of the public's understanding of these different terms was done by questionnaire. Each of some 200 adults chosen as a random stratified sample from the electoral rolls of the wards of Kitchener-Waterloo was interviewed personally. There were no refusals. 75% of the respondents were between 21 and 50 years old and two out of every three of those interviewed were male. The composite results of the questionnaire are shown in the appendix to this article.

SPECIFIC CONCLUSIONS

A. Terms with a Definite Meteorological Definition

1. Question 11 - "clear"

With exactly half of the respondents believing it to mean no cloud cover, and a further 46% believing it to mean less than 2/10 cloud cover, the correct answer of less than 4/10 cloud cover is clearly not understood. Since the Oxford Dictionary defines "clear" as "free from clouds" (Oxford English Dictionary, 1961) and Webster's Dictionary states "less than 1/10 covered" (Webster's Third New International Dictionary, 1966) the respondents viewpoint is not altogether surprising.

2. Question 24 - "sunny"

Again, there is clear indication of misinterpretation of an official term. Considerable agreement (66%) exists about its meaning, so it seems to be an acceptable word, but for quite the wrong definition - less than 4/10 cloud cover as opposed to the correct definition of less

than 7/10 cloud cover. The fact that 27% chose less than 8/10 cloud cover is intriguing, but for the most it seems that unless "sunny" can mean less than 4/10 cloud cover the term is something of a misnomer. Webster's Dictionary defines "sunny" as "characterized by brilliant sunlight" and the Oxford Dictionary states "full of sunshine", thus the "lay" meanings of both "clear" and "sunny", as learned in the normal socialization and educational processes, are quite at odds with meteorological terminology. (Just how accurately the public is able to differentiate between different amounts of cloud cover is another thing again, and raises its own issues.)

3. Question 17 - "mostly sunny"

The replies concerning this term seem to suggest, first and foremost, that the less precise nature of statement (b), "it will be a sunny day with occasional cloudy periods" has more meaning to the lay public than the more quantitative, complex, but correct answer (c). However, related to this is the implication from question 24 that less than 7/10 cloud cover is too high to represent the notion of "sunny", even when qualified by the term "mostly", but even less than 5/10 cloud cover received only 9% of answers so the general conclusion must be a preference for, or understanding of, loose terminology.

4. Question 13 - "cloudy"

The term "cloudy" fared somewhat better than "clear" gaining 35% of the replies for the correct definition (c) of 7/10 or more cloud cover. However, the majority of people seem to need somewhat less cloud cover for them to "experience" cloudy conditions. Perhaps a reduction in cloud cover in official terminology would be more appropriate.

5. Question 21 - "overcast"

The term seems to be well understood.

6. Question 22 - "calm"

This is a restricted term since "winds of less than 20 m.p.h. will be included at the forecaster's discretion" (MANPUB, section 3.8.5.1. (4)).

According to the Beaufort Scale, winds less than 1 m.p.h. constitute "calm" conditions, and 35% chose this answer, but with 49% choosing 2 - 7 m.p.h. winds it does seem as though most people view "calm" as equivalent to very slight breezes. Again the meteorological definition is somewhat at odds with the Oxford Dictionary meaning which defines "calm" as "without wind". Webster's Dictionary defines "calm" as a "complete absence of wind" or "presence of wind having a speed no greater than one mile per hour".

7. Question 25 - "light breeze"

This is also a restricted term, falling under section 3.8.5.1.(4) of the manual MANPUB. It is highly acceptable and well understood by the respondents.

8. Question 8 - "moderate winds"

Generally speaking, "moderate winds" seem to imply something stronger than "light breezes" but not, on the whole, as strong as the official conditions of 15 - 20 m.p.h. (only 14% of replies chose this range). Again, a lowered range may be more akin to the public's perception.

9. Question 16 - "gusts of wind"

Although slightly over half the respondents correctly chose gusts to exceed 18 m.p.h., the other half was almost equally divided between the 10 m.p.h. maximum, and the 30 m.p.h. maximum which suggests some confusion and raises the question as to whether the 18 m.p.h. was guessed at being most appropriate by virtue of its middle range and therefore a fair compromise! Perhaps a four-part question would provide more reliable results.

B. Terms in Manual Generally Understood by Public but with No Set Meaning

The terms "showers", "snow flurries", "snow", "thunderstorms", and "freezing rain" are all unqualified terms used by weather forecasters and are believed to be generally well understood. According to MANPUB section 3.8.1.6:

> "The term "showers" and corresponding terms "snow flurries", "snow showers"--are to be used only when the precipitation is expected to last for relatively short periods (less than half an hour)."

1. Question 9 - "showers"

Although short intervals of light rainfall is the most popular answer (56%), the brevity of time period is probably the more significant factor in the individual's perception of "showers", in which case the loose MANPUB definition seems quite appropriate.

2. Question 6 - "snow flurries"

Clearly, "snow flurries" implies a very small accumulation of snow and probably again the intermittent factor, like "showers", is the most significant element of perception. An appropriate definition might be "short periods of falling snow leading to an accumulation of less than one inch of snow".

3. Question 19 - "occasional snow"

The replies to this question are rather reminiscent of question 17 in terms of the very definite preference (83%) for the "loose" definition of "brief periods of snow falling".

4. Question 14 - "freezing rain"

The term seems to be well understood (88% correct) and should be retained as is.

C. Probabilities in Weather Terminology

In section 3.8.6 of MANPUB, probability is defined as being:

> "restricted to descriptive terms to be used in those weather situations which make the occurrence of precipitation and/or strong winds a possibility even though the preponderance of evidence suggests otherwise. It is important, however, that this type of terminology be used sparingly in order that it will not be interpreted as simply 'hedge' on the part of the forecaster."

> "3.8.6.1. To indicate the possibility of the occurrence of precipitation and /or strong winds the terms 'slight chance of' or 'chance of' may be used."

It should be noted that the MANPUB's meaning of probability is where a slight "possibility" or "chance" of occurrence is anticipated. But in most people's minds, and certainly in dictionaries "probability" is given a stronger implication - "likely to be true" (Oxford Dictionary), and "can fairly convincingly be accepted as true" (Webster's Dictionary). "Possibly" on the other hand, conjures up some doubt in the mind - "perhaps" (Oxford Dictionary) or "by merest chance" (Webster's Dictionary).

The public's reaction to "probabilities" may be seen in the interpretation given to "likely" in question 7 and "chance" in question 23. Clearly there is no agreement in statistical terms as to the degree of probability for either term, though one might infer that "chance" has a lower probability than "likelihood" having 77% of answers below 50% probability, compared with 56% for the term "likely". The word "probable" itself was not tested. Surprisingly, Rogell's classification, which seems so appropriate, does not seem to be in evidence here (although the numerical ranges used in the two questionnaires do differ by 1%).

Up until January 31, 1972, the terms "mild", "cool", and "cold" were treated as absolute terms assigned to a specific temperature range normal for the time of year. These have now been replaced by comparative terms, e.g., "cooler" and "continuing mild" to the previous day's weather.

Questions 5, 10, and 14 probed the effect of "absolute" meanings, whereas question 26 was comparative in nature. At first glance little agreement exists with regard to <u>absolute</u> temperature figures appropriate for such terms as "mild", "cool", and "cold" when considered seasonably, i.e., considered in relation to a seasonal norm. However, by aggregating results, admittedly in a most arbitrary fashion, one might suggest that the term "mild" (question 5) suggests temperatures within the range of 40 - 59°F to 74% of respondents for spring, and to 76% of respondents for fall, 82% of answers fall in the 20 - 39°F for winter whereas 59% chose 60 - 69°F for summer, (35% finding no answer given applicable for that season, all being presumably too low).

Agreement on "cool" (question 10) is even less marked, although 73% thought 50 - 59°F temperatures were "cool" for summer, and, in

aggregate, 63% felt 10 - 29°F a "cool" range for winter. Spring and fall results exhibit even less consensus.

Temperatures within the scale 36 - 50°F appeared low enough to warrant the term "cold" (question 14) in summer to 73% of the respondents although a further 16% felt no answer was appropriate. The results for the other seasons are not so striking but one might posit from them that 5°F establishes a threshold for "cold" in winter, whereas in fall below 35°F seems most applicable.

However, the notion of a relative meaning, e.g., "cooler" (question 26), defined in terms of a certain temperature drop from the previous day, is not particularly well understood either. The temperature range gaining most support (54%), a 7 - 8°F drop, is an incorrect definition for the K-W area which instead looks to a 5 - 6°F drop (27% of replies) as constituting "cooler" temperatures for the region. Clearly, some clarification or further inquiry is warranted on this question of absolute as opposed to comparative definitions.

D. Terms Used by Media but Not Recommended by MANPUB

1. Question 15 - "partly cloudy"

According to MANPUB section 3.8.2.3:

> "the term 'partly cloudy' is not recommended because of the lack of agreement within individual offices, and from office to office, as to its meaning and appropriate use."

At first glance, section (b), "the day will be sunny with occasional cloudy periods", seems a popular connotation, having 58% of the replies. However, since both "cloudy" and "sunny" in their official senses were poorly understood (see questions 18 and 24), it does seem as though the term "partly cloudy" is best unused.

2. Question 18 - "wind chill factor"

The generally understood meaning of "wind chill factor", that of section (b), received slightly over half the replies and would probably have had a much higher percentage had the answer been worded more specifically as "a combination of low temperatures and wind speed---" rather than the use of the word temperature alone which might tend to suggest warm conditions. It is felt that the terminology might well be accepted by the Atmospheric Environment Service.

E. Summary of Specific Conclusions

This study has suggested the following to be the case for the Kitchener-Waterloo region.

1. Terms well understood with respect to official definitions: "light breezes","overcast".

2. Terms not well understood with respect to official definitions: "clear", "sunny", "cloudy", "moderate winds", "mostly sunny", "calm".

3. Terms with no special definition, but considerable consensus: "showers", "snow flurries", "freezing rain", and "occasional snow".

4. Terms with no special definition, and little consensus: "chance", and "likelihood".

It might therefore be suggested that:

1. "Clear" be considered to apply when cloud cover is minimal. 1/10 cloud cover might be an appropriate figure, but certainly no more than 2/10 cloud cover.

2. "sunny" be redefined to apply when cloud cover is less than 4/10.

3. "cloudy" be redefined to apply when over 6/10 of the sky is covered by cloud. The intervening condition, i.e., cloud cover between 4/10 and 6/10 might well be termed "mainly sunny".

4. "calm" not be used unless wind conditions are very slight. 5 m.p.h. might be an appropriate maximum, beyond which the term "light breeze" would conveniently apply.

5. "moderate winds" might appropriately provide the range of conditions following "light breezes", i.e., 9 - 20 m.p.h.

6. "showers" might be used simply to mean short intervals of rainfall.

GENERAL CONCLUSIONS

There is little doubt that certain forecasting terms are widely misinterpreted. To improve the understanding of forecasts, therefore, either the public must be re-educated to associate the official meaning with the use of the term, or ofiicial terms must be more in key with the general comprehension of them. Where considerable consensus exists for a "wrong" meaning, there is some validity in considering re-

definition but then the question is raised as to standardized usage in the national setting. The "public" of one region may be quite different in their interpretation of terminology from the "public" of another region, and one is always left wondering just how representative any surveyed sample is, even if carried out on a rigorous quantitative basis.

It seems clear that in media of national reception some form of standard definition does seem necessary. But for media predominantly localized in reception, slightly different meanings might be acceptable if apparently more consistent with the "regional" public's views. Already this occurs with respect to temperature drop, and occurred in the past with "mild", "cool", and "cold".

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APPENDIX

Kitchener - Waterloo Study

Questionnaire on Weather Terminology

Note: The official AES definition of terms is indicated by an asterisk. The composite results for each question are shown in brackets.

1. How often do you normally read, listen or watch the weather forecast? Please check the number of times and the sources.

	Newspaper	Radio	Television
a) every day	(33%)	(59%)	(36%)
b) almost every day	(14%)	(17%)	(28%)
c) before weekends	(2%)	(3%)	(4%)
d) hardly ever	(22%)	(6%)	(16%)
e) read, listen or watch but do not usually pay attention	(3%)	(3%)	(2%)
f) no answer	(26%)	(12%)	(14%)

2. Please indicate the comment you would use to describe each of the three listed sources of weather information.

	Newspaper	Radio	Television
a) understandable	(35%)	(40%)	(42%)
b) hard to understand	(7%)	(2%)	(1%)
c) forecasts are given too quickly	(1%)	(9%)	(4%)
d) more information should be provided	(14%)	(11%)	(5%)
e) forecasts are satisfactory	(23%)	(29%)	(33%)
f) no answer	(20%)	(9%)	(15%)

3. Please rank these items of the weather forecast in order of importance to you. (Number 1 is most important, number 5 is least important.)

a) the temperature expected tomorrow	(1.63 average ranking)
b) how clear or cloudy tomorrow's sky will be	(2.97 average ranking)
c) the expected wind speed tomorrow	(3.55 average ranking)
d) the precipitation (rain, snow) expected tomorrow	(1.80 average ranking)
e) the barometric pressure expected tomorrow	(4.57 average ranking)

4. Which of the following forecasts on precipitation (rain, snow) would be most acceptable to you. Please check one only.

a)	Cloudy today, rain tonight, clearing tomorrow	(55%)
b)	Rain probability today 40%, tonight 80%, tomorrow 30%	(14%)
c)	Cloudy today, with rain probability 40%, rain tonight with rain probability 80%, clearing tomorrow with rain probability 30%	(31%)

5. For each season indicate the temperature range for which a forecast of "mild" today would apply. Please check only one for each season.

	Temperature	Spring	Summer	Fall	Winter
a)	20 - 29°F	(5%)	(1%)	(1%)	(41%)
b)	30 - 39°F	(11%)	(0%)	(7%)	(41%)
c)	40 - 49°F	(43%)	(1%)	(29%)	(11%)
d)	50 - 59°F	(31%)	(4%)	(47%)	(2%)
e)	60 - 69°F	(9%)	(59%)	(13%)	(1%)
f)	the term does not seem applicable for this season	(1%)	(35%)	(3%)	(4%)

6. If in the morning you hear a forecast for "snow flurries" this afternoon, by late evening you would expect: (please check only one.)

a)	little or no new snow	(33%)
b)	less than 1 inch of snow	(51%)
c)	1 - 2 inches of snow	(13%)
d)	2 - 4 inches of snow	(2%)
e)	no answer	(1%)

7. If in the morning you hear a forecast for "thunderstorms" likely this afternoon, what is the chance of a thunderstorm occurring that afternoon? Please check only one.

a)	1 - 19%	(15%)
b)	20 - 29%	(13%)
c)	30 - 49%	(28%)
d)	50 - 69%	(26%)
e)	70% or more	(17%)
f)	no answer	(1%)

8. What does the term "moderate winds" mean to you? Please check only one.

	a)	wind speeds between 5 - 8 miles per hour	(26%)
	b)	wind speeds between 9 - 14 miles per hour	(58%)
*	c)	wind speeds between 15 - 20 miles per hour	(14%)
	d)	wind speeds between 21 - 25 miles per hour	(2%)

9. What does the term "showers" mean to you? Please check only one.

a)	short-intervals of light rainfall	(56%)
b)	short-intervals of heavy rainfall	(26%)
c)	long-intervals of light rainfall	(17%)
d)	long-intervals of heavy rainfall	(1%)

10. For each season indicate the temperature range for which a forecast of "cool" today would apply. Please check only one for each season.

	Temperature	Spring	Summer	Fall	Winter
a)	10 - 19°F	(8%)	(1%)	(4%)	(45%)
b)	20 - 29°F	(28%)	(2%)	(20%)	(18%)
c)	30 - 39°F	(37%)	(3%)	(40%)	(5%)
d)	40 - 49°F	(19%)	(9%)	(29%)	(1%)
e)	50 - 59°F	(4%)	(73%)	(3%)	(0%)
f)	This term does not seem applicable for this season	(3%)	(11%)	(3%)	(28%)
g)	no answer	(1%)	(1%)	(1%)	(1%)

11. What does the term "clear" skies mean to you? Please check only one.

a)	No visible clouds	(50%)
b)	Less than 2/10 of the sky is covered with clouds	(46%)
* c)	Less than 4/10 of the sky is covered with clouds	(2%)
d)	Less than 6/10 of the sky is covered with clouds	(2%)

12. What does the term "freezing rain" mean to you? Please check only one.

a)	rain that falls in liquid form but freezes upon impact to form a coating of ice	(88%)
b)	a form of precipitation that although frozen at higher elevations, arrives at the surface as cold rain	(5%)
c)	rain followed by freezing temperatures later on in the day which leads to the formation of ice	(4%)
d)	other (please specify)	(3%)

13. What does the term "cloudy" skies mean to you? Please check only one.

a)	the sky will be 1/10 to 4/10 covered with clouds	(13%)
b)	the sky will be 5/10 to 6/10 covered with clouds	(51%)
* c)	7/10 or more of the sky is cloud covered	(35%)
d)	no answer	(1%)

14. For each season indicate the temperature range for which a forecast of "cold" today would apply. Please check only one for each season.

	Temperature	Spring	Summer	Fall	Winter
a)	-25 to -11°F	(0%)	(0%)	(0%)	(37%)
b)	-10 to -5°F	(9%)	(0%)	(5%)	(49%)
c)	6 to 20°F	(35%)	(1%)	(19%)	(10%)
d)	21 to 35°F	(43%)	(8%)	(63%)	(0%)
e)	36 to 50°F	(9%)	(73%)	(10%)	(1%)
f)	not applicable for this season	(2%)	(16%)	(1%)	(1%)
g)	no answer	(2%)	(2%)	(2%)	(2%)

15. What does a "partly cloudy" day mean to you? Please check only one.

a) the day will be cloudy with occasional periods of sunshine (29%)
b) the day will be sunny with occasional cloudy periods (58%)
c) the day will consist of about 50% clouds and 50% sunshine (12%)
d) no answer (1%)

16. What does "gusts of wind" mean to you? Please check only one.

a) brief periods during which the normal wind speed increases to 10 miles per hour or more (21%)
* b) brief and rapid increase in the wind speed, and the speed fluctuates by 10 miles per hour or more between peaks and lows and the maximum speeds attained in the gusts exceed 18 miles per hour (53%)
c) brief periods during which the wind speed increases to 30 miles per hour or more (26%)

17. What does a "mostly sunny" day mean to you? Please check only one.

a) the day will be cloudy in the morning and sunny in the afternoon (5%)
b) it will be a sunny day with occasional cloudy periods (76%)
* c) for most of the day the sky will be less than 7/10 cloud covered but there will be periods of 3-4 hours when the sky will be 7/10 or more cloud covered (10%)
d) for most of the day the sky will be less than 5/10 cloud covered but there will be periods of 3-4 hours when the sky will be more than 5/10 cloud covered (9%)

18. What does "wind chill factor" mean to you? Please check only one.

a) a combination of wind speed and humidity which makes you feel colder than you would expect it to be after hearing the actual temperature from a forecast (24%)
b) a combination of temperature and wind speed which makes you feel colder than you would expect it to be after hearing the actual temperature from a forecast (52%)
c) a lowering of the actual temperature due to strong winds (24%)

19. If in the morning you hear a forecast for "occasional snow this afternoon" you would expect: (Please check only one.)

a)	snow falling most of the afternoon	(6%)
b)	several inches of new snow	(1%)
c)	brief periods of snow falling	(83%)
d)	on the average, snow fall will start and stop once or twice an hour during the forecast period	(10%)

20. What does "very cold" mean to you? Please check only one.

a)	25 to 35°F	(3%)
b)	15 to 24°F	(0%)
c)	0 to 14°F	(26%)
d)	-15 to -1°F	(30%)
e)	-25 to -16°F	(41%)

21. What does "overcast" skies mean to you? Please check only one.

a)	the same as "cloudy skies"	(9%)
b)	more cloud cover than a forecast for cloudy skies	(12%)
c)	less cloud cover than a forecast for cloudy skies	(3%)
* d)	complete sky cover giving dull grey conditions	(74%)
e)	no answer	(2%)

22. What does "calm" conditions mean to you? Please check only one.

a)	no wind detectable at all	(3%)
* b)	winds less than 1 mile per hour	(37%)
c)	winds between 2 - 7 miles per hour	(49%)
d)	a gentle breeze, winds 8 - 12 miles per hour	(10%)
e)	no answer	(1%)

23. If in the morning you hear a forecast for "a chance of showers this afternoon", what is the probability of showers occurring that afternoon? Please check only one.

a)	1 - 19%	(17%)
b)	20 - 29%	(34%)
c)	30 - 49%	(26%)
d)	50 - 69%	(14%)
e)	70% or more	(8%)
f)	no answer	(1%)

24. What does a "sunny" day mean to you? Please check only one.

a)	less than 8/10 of the sky will be cloud covered	(27%)
* b)	less than 7/10 of the sky will be cloud covered	(6%)
c)	less than 6/10 of the sky will be cloud covered	(0%)
d)	less than 5/10 of the sky will be cloud covered	(0%)
e)	less than 4/10 of the sky will be cloud covered	(66%)
f)	no answer	(1%)

25. What does "light breeze" mean to you? Please check only one.

* a)	wind speeds between 5 - 8 miles per hour	(77%)
b)	wind speeds between 9 - 14 miles per hour	(19%)
c)	wind speeds between 15 - 20 miles per hour	(1%)
d)	wind speeds between 21 - 25 miles per hour	(2%)
e)	no answer	(1%)

26. If at night you hear a forecast for "cooler temperatures" tomorrow, you would expect: (Please check only one.)

a)	a 0 - 2 F degree drop in temperature	(3%)
b)	a 3 - 4 F degree drop in temperature	(14%)
c)	a 5 - 6 F degree drop in temperature	(27%)
d)	a 7 - 8 F degree drop in temperature	(54%)
e)	no answer	(2%)

27. Sex: male (130)
female (70)

28. Please indicate your age group:

a)	20 or under	(12%)
b)	21 - 35	(49%)
c)	36 - 50	(26%)
d)	51 - 64	(12%)
e)	65 or over	(1%)

29. Please state your occupation: _____

30. To what extent do weather forecasts affect your occupation in terms of money losses or gains? Please check only one.

a)	not at all	(72%)
b)	slight effect	(16%)
c)	great effect	(10%)
d)	no answer	(1%)

31. Are most of your recreational activities related to: (Please check only one.)

a)	indoor activities	(44%)
b)	outdoor activities	(56%)

32. To what extent do weather forecasts affect your recreational activities? Please check only one.

a)	not at all	(22%)
b)	slight effect	(43%)
c)	great effect	(34%)
d)	no answer	(1%)

This is the end of the questionnaire. Thank you very much for your co-operation.

NEWS AND COMMENTS

The 1974 meeting of Friends of Climatology was held in Ottawa on March 15-16. The meeting was organised by Dr. Wolfgang Baier and his colleagues in the Agrometeorological Research and Service Section of the Chemistry and Biology Research Institute of Agriculture Canada. The afternoon of Friday, March 15, was devoted to an open house in agrometeorology at the Central Experimental Farm at which the different research scientists of the Agrometeorological Section were available to discuss their research programmes. This gave everyone an opportunity to examine and discuss informally a number of aspects of applied meteorology and climatology.

On Friday evening there was a cocktail hour, followed by a buffet dinner at the Talisman Hotel. The Talisman Hotel was also the location of a session on Saturday morning, March 16, divided essentially into two parts. The first part was occupied with a lively and provocative 90-minute discussion dealing with the climatic aspects of world food production and agricultural development. Particular attention was given to the famine and food problems of West Africa, to the question of the recent expansion of the snow-covered and frozen area of the northern hemisphere, and to the possibilities of climatic prediction and the form which it should take to be useful in a human context. After a coffee break, the meeting discussed and heard reports on a number of matters concerning Canadian research developments and contributions to international agencies.

Three items of business concluded the meeting: Christopher Sparrow outlined and reported on the work done by Ontario climatologists in promoting work in educational institutions; Marie Sanderson announced the publication of a Directory of Friends of Climatology; and it was decided to hold the 1975 meeting on the University of Toronto Campus at Scarborough College.

The Rockefeller Foundation held a two-day meeting of climatologists and food-supply specialists on January 24 and 25, 1974. The proceedings were widely publicised through the New York Times, and were devoted to the question: What effect may climatic change have on world food supplies?

One view, strongly supported by Reid Bryson, was that world climate had entered a cold phase in which increased variability was likely to produce more frequent crop failures or losses in many of the crop producing areas. This change was in part man-induced due to increased particle loading of the atmosphere. Others were less sure that the mechanisms proposed were sufficient to cause major changes, but there was general concern over the irreversible spread of the Sahara in the Sahelian Zone of West Africa.

Lester Brown spoke of the immense impact that the 1972 anomalies of climate had had on world food exports and on reserves. These had at one time fallen below sixty days supply, and grain prices had risen spectacularly. The U.S. "soilbank" lands held out of production for many years, with a potential yield of 100 million tons per annum, had all been brought back into cultivation.

The meeting was not intended to reach firm conclusions or to make recommendations: and it did not, in fact, do so.

The University of Quebec at Montreal has recently established a Centre for Research in the Environmental Sciences. The research programme comprises four sections: (a) "Cytology and Ecological Models", directed by Pierre Legendre; (b) "Ecology and Management", directed by Pierre Danserau; (c) "The Surface Water Environment", directed by André Chodorowski; and (d) "The Atmospheric Environment", directed by Conrad East. The latter section will be of particular interest to climatologists. Its emphasis will be upon air quality and atmospheric pollution and the meteorological conditions influencing their character, occurrence, and transport over long distances.

The same University has also established a Master's programme in Ecology. It is open to those having a cumulative B grade average or equivalent in a Bachelor's degree in one of the following: biology, chemistry, physical geography, physics, earth sciences, agriculture, or engineering. A degree considered to be equivalent to the foregoing is also acceptable.

A Directory of "Friends of Climatology" is now available. It has been compiled by Marie Sanderson and Russell Thompson and contains the names, addresses, research interests, and selected publication lists for a total of 71 climatologicts working in Canada and the United States. The Directory costs two dollars ($2.00) and can be obtained from: Dr. Marie Sanderson, Department of Geography, University of Windsor, Windsor, Ontario.

Since the last number of Climatological Bulletin was published, two Masters theses in climatology have been accepted by McGill University:

(a) "Solar and Net Radiation over Snow in a Sub-Arctic Environment" by Don E. Petzold.

(b) "Potential Evapotranspiration in Different Climatic Regions of Guyana" by Chander Persaud.

The Atmospheric Environment Service has recently published "A Bibliography of Canadian Climate, 1958-71" compiled by Morley K. Thomas. It continues the information given in an earlier volume published in 1962 and covering the period 1763-1957. Like its predecessor, the current volume is bilingual. Its price is two dollars ($2.00) and is available from Information Canada and booksellers, catalogue no. En 56-4373.

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