The Rise and Fall of Climate Applications: The History of a Meteorological Service Program

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1. Dedication

This publication is dedicated to Gordon McKay, former Chief of the Applications and Impact Division, Director of the Climate Applications Branch and Director General of the Canadian Climate Centre. For many years he was Canada's leading advocate of the benefits of applying climate information.

It is also dedicated to the many people who worked in the Applications and Impact Division over the years, and were responsible for its many successes.

2. Summary

This paper gives a brief history of climate applications in the Meteorological Service of Canada. Climate applications refers to the analysis of climate information to meet the needs of specific users, for example in agriculture, solar and wind energy, forestry, and building design. Hydrometeorology can also be considered as climate applications, but is not discussed in any detail in this history. Also, the study concentrates on MSC headquarters activities, excluding work done by regional offices.

Prior to the 1950's little climate applications work was done by MSC - information provided was in the form of tabulations and maps, most of which provided general information intended for a variety of users. Tables of mean monthly precipitation, or maps of mean annual temperature were examples. Occasionally, regional of national climatologies were also published, for example, the *Climate of Ontario.*

The post World War II period saw a sharp increase in the demand for climate information tailored to the needs of specific users. MSC's initial response, starting in 1953, was to lend climatologists to other government agencies to meet these demands. These seconded climatologists were posted to the National Research Council's Division of Building Research, the federal Departments of Agriculture and Forestry, the B.C. Department of Forestry, and the Ontario government.

In the late 1950's, MSC also began to develop an in-house capability in climate applications, with the creation of hydrometeorological and arctic climatology sections. A bioclimatology section was added shortly thereafter. Bioclimatology concentrated on agricultural and forestry applications. By the early 1960's, MSC had about 12 professionals working in climate applications, with roughly half being seconded to other agencies. Around 5 of these 12 worked in hydrometeorological applications.

The period from the mid-1960's to mid-1970's saw a number of changes which affected MSC's climate applications program. The seconded climatologist

program was phased out. The energy crisis that started in 1973, combined with increasing concerns with environmental issues, resulted in another sharp increase in demand for climate applications products, especially in relation to offshore and renewable energy development. This period also saw a rapid expansion in the role of governments in Canada, with an accompanying increase in demand for climatological information, for example for planning new parks and other recreation facilities. In response, MSC headquarters climate applications (excluding hydrometeorology and some regional activities) were consolidated into a single Applications and Impact Division, under the leadership of Gordon McKay. The number of professional applications specialists doubled, from about 7 to 15. In addition, by the end of the 1970's, large amount of supplemental funding was added to the Division's budget, mainly to expand its program by hiring contractors. In 1965 computers were introduced into MSC climatology, greatly facilitating data analysis for applications work.

From the 1970's to the 1990's, the Applications and Impact Division's primary areas of work were Industrial Climatology, Arctic Climatology and Bioclimatology. Recreation and tourism climate was also a major area of activity until the early 1980's. Industrial climatology was concerned primarily with applications to solar and wind energy development, and to the design of buildings and other structures. Much of Arctic's work was in support of offshore petroleum development, and the associated environmental issues. Support to forestry and agriculture were the main activities in Bioclimatology. In the 1970's climate change issues were a minor concern, but in the 1980's they became increasingly important, especially in Arctic and Bioclimatology. Since the Division was Canada's leading centre of expertise in climate applications, it was called upon to provide analysis and advice in a wide variety of other areas as well – a few examples were human health, ship-hull design, nuclear waste disposal, reconstruction of past climate, urban snow clearing and land-use planning on the fringes of urban areas.

The years between the mid-1980's and mid-1990's saw major changes in government priorities as they affected climate applications. Oil prices had dropped dramatically, and along with them, government and industry concern about energy supply issues. Government expansion changed to government contraction as budget deficits became of increasing concern. In the federal civil service, more emphasis was placed on meeting the needs of its political masters. In climatology the primary issue, at least at the political level, had become the possible effects of climate change caused by increased concentrations of atmospheric greenhouse gases. The net result of these changes was the elimination of most of the climate applications program which had been developed since the 1950's. The main exception was work on the effects of climate change, most of which was transferred to universities, along with some MSC applications specialists, who kept their affiliation with the Service. While this university based work can probably still be called climate applications, its nature has changed in a number of ways. For example, it is more multidisciplinary. Also it contains a distinctly speculative element, since it is rarely possible to precisely predict the long-term effects of a changing climate on ecosystems or societies.

3. Introduction

Why write this history? Between the 1950's and 1970's, work in climate applications grew dramatically in the Canadian Government's Meteorological Service of Canada (MSC). From the 1960's until 1991 the Applications and Impact Division (AID) provided a national centre of expertise on the subject. It was dismantled in 1991, ending a substantial part of the Federal Government's applications work. Over the 37 years it and its predecessors existed, more than 100 people worked on applications, providing information and advice to a large number of clients, and providing major advances in applied climatology. Some record of their endeavours needs to be preserved, and an attempt made to place these efforts in the context of changes that occurred in the government and elsewhere during this period.

This history centres on the period 1980 to 1990, since this is the period when more detailed information is available. However an attempt has been made to describe earlier developments. Even for the 1980's, information is limited. For example, information is lacking on the following:

- The extensive work that staff did in meetings, working groups, conferences, etc.
- Information about individual AID staff members, especially technical staff.
- The influence of senior managers on AID's activities

It would be nice to think that this history would be fascinating to a large audience. In reality, it is likely to be of interest mainly to those who worked in AID, or at least those who have interests in applied climatology. Given the limited potential audience, my research for this project has not been complete. More could certainly be done.

Since I managed AID for most of the 1980's, it would have been easy for me to write a biased history, turning it into an "everything-we-did-was-wonderful" effort, and portraying the Division's eventual dismantling as a truly villainous act. I've tried hard to avoid this, and keep my objectively. I leave it to knowledgeable readers to decide whether I've succeeded.

Organization names and abbreviations

Various organizational units mentioned frequently in this publication have changed names over the years. Some of these changes are discussed in

Sections 4. In the hope of avoiding confusion, I have in most places used the first name listed in the following:

- The Applications & Impact Division (AID) was also known as Climate Research & Special Programs, Applications & Consultation, and Analysis & Impact
- The Climate Applications Branch (of which AID was one of part) was also know as the Meteorological Applications Branch, the Climatology Division and the Climatology Section
- The Meteorological Service of Canada (MSC) was also called the Meteorological Division (1936-56), the Meteorological Branch (1956-69), the Canadian Meteorological Service (1969-71), and the Atmospheric Environment Service (1971-99).
- The Atmospheric and Climate Science Directorate (ACSD) was also called The Atmospheric Research Directorate and the Climate and Atmospheric Research Directorate.
- Arctic Climatology, Physical Climatology, Bioclimatology and Energy & Industrial Climatology - changes in the names of these AID Sections for the 1980-90 period are described in Figure 3, earlier changes in Appendix D.

Where to find it

The main part of this history sketches developments up to 1980, then provides usually brief discussions of AID activities from 1980 onwards. Appendix A contains more detailed descriptions and discussions of about 28 projects selected from most years in the 1980's and part of the 1990's.

Thanks to

Thanks to all those who have provided information, and comments on this material. In particular, Morley Thomas, MSC historian, climatologist, and retired Director-General of the Canadian Climate Centre, provided valuable assistance in preparing the pre-1980 portion. Bruce Findlay, one of AID's most experienced climatologists, provided advice on a wide variety of items.

4. Sorting out the Terminology - Climate Services, Applications, Impacts, Adaptation, Research

Readers with an aversion to discussions of jargon may to be tempted to skip this section. However it is useful in understanding climate applications, and the evolution of AID's program.

Climate applications

For many years, climatology in MSC could be thought of as including three types of activity – climate services, climate applications and climate research. Climate services responded to routine requests for information. In support of this role, it prepared summaries of climate data in the form of tabulations, maps, etc., which are usually intended for a broad range of users. For example, a question like "Is it hot in Vancouver in July?" could be answered to the satisfaction of many simply by looking at a table of monthly temperatures for that city.

However if an answer is needed to the question "Will the climate of the Peace River region allow the successful growth of wheat most years?", then expert analysis and interpretation of climate information is needed. This is climate applications. Since the ecosystem and many human activities are sensitive to climate, the applications specialist's task is to provide the information required to properly take these sensitivities into account. Because successful applications work requires considerable knowledge of other disciplines, or area of human activity, individuals working in the area usually specialize, e.g. in applications to agriculture, forestry, or the construction industry.

Climatological applications does not include the development of models of atmospheric behavior based on the understanding of physical processes, which is the responsibility of climate research. It may however include the use of models developed by researchers. For an example of using models to estimate solar radiation, see McKay's *A Merged Solar and Meteorological Database*. Climate applications may also included the development of empirical relationships, for example between winds at a coastal observing station and those offshore, e.g. Maxwell's *The Climate of Northwestern Baffin Bay.*

Climate impacts

Climate impacts simply refers to the effects of climate on ecosystems or human activities. Distinguishing climate impacts from climate applications became popular in the 1980's. Prior to that time, it was simply recognized that applications specialists had at times to make impacts analysis part of their studies, often in cooperation with workers from other disciplines. William's

Measuring Agricultural Productivity as a Function of Climate is a case in point. This work, begun in the 1970's, relates climate to wheat yield.

Use of the term "climate impacts" emphasized the relevance of climatologists' work. This was particularly important in the case of climate change. It was difficult to convince audiences of the importance of this issue by talking about global warming of 3C. It was necessary to talk about impacts - dying forests, barren rice paddies, submerged islands and the like. The shift in emphasis is illustrated by the change in AID's name in the late 1970's from "Applications and Consultation" to "Applications and Impact".

In this history, "climate applications" is frequently used to mean both climate applications and climate impacts.

Climate adaptation

"Climate adaptation" was a term that became popular in the 1990's. Again, this was influenced by the climate change issue. If the proponents of the issue talked about, to repeat the previous example, dying forests, barren rice paddies and submerged islands, critics would state that ecosystems and humans would simply adapt, for example with new tree species, crops that needed less water than rice, or movement from low-lying areas to higher ground. Hence the need to study to what extent adaptation was possible, and at what price. Climate adaptation differs from the activities discussed previously in that it falls more into the realm of disciplines other than climatology. When climatologists are involved in this work, it is usually indicative of knowledge they have acquired in these other disciplines.

Climate research

An anonymous discussion paper on "The Research versus Applications Dispute", prepared shortly after the reorganization of MSC into Environment Canada in 1972, attempts to differentiate research from applications. The author typifies climate applications' objective as solving "other people's problems" while research is aimed at "the extension of meteorological knowledge". The paper does go on however to recognize there was overlap between the two functions in MSC, using air pollution work in the research group (ACSD) as an example.

It is not surprising that the title of this paper implies a dispute over the relative roles of applications and research. Some activities of ACSD are clearly research. As mentioned previously, development of a general circulation (numeric) model of the earth's atmosphere to predict climate change is an example. However, government research groups are expected to produce practical results, in line with government priorities, rather than to simply produce an "extension of meteorological knowledge". As a result, they at times employ techniques similar to those used by climate applications specialists, and their work becomes indistinguishable from applications.

What happened to the term “climate applications”?

Starting around the mid-1980’s, the term climate applications tended to go out of use in MSC, to be replaced by climate impacts and later, climate adaptation. This will be discussed in Section 6. However, it is worthwhile considering here the reaction of a typical climate applications specialist from, say 1970, if it were possible to transport him forward in time to 2001. It is very likely he would view most of what MSC now calls climate impacts as climate applications. He would note changes - the narrowing of the work to climate change issues, the increased involvement of climatologists in impacts assessment, the increased tendency to work in multidisciplinary teams. But these would be viewed as changes in emphasis rather than fundamentals.

5. The Rise of Climate Applications - A Pre-1980 History

5.1 Canadian climatology before 1950

Although there had been interest in climatology in MSC as early as 1871, it was not until 1890 that a climatologist position was created, and filled by Hugh V. Payne, a former forecaster and station inspector, whose title soon became "Dominion Climatologist." In 1891 the Director of MSC reported to the Deputy Minister that there were two branches at the Central Office - the Climatological Branch and the Forecast Branch. When Payne died in 1911, A.J. Connor, an MA in classics, became responsible for climatology. He had joined the service in 1907, recruited as a person "of literary ability", to write a climate of Canada. Another professional, E.G. McDougal, was hired in 1917 to look after agricultural meteorology; he left in 1926. At some point, Connor took over responsibility for both climatology and agricultural meteorology.

A glimpse at pre-World War II climate activities in MSC is given by the 1935-36 Record of Operations. About 1000 requests for information were handled. These included the “computation of absolute humidity and diurnal variability of temperatures for engineers and manufactures”. Wind summaries were prepared for the Air Ministry of Great Britain. Monthly weather maps and the Monthly Records of Meteorological Observations were published. Work on a book, “The Climate of Canada” was underway, as were climate maps for an “Atlas of Canada”.

During World War II MSC’s focus was primarily on weather forecasting, especially in support of wartime aviation. However, the Climatological Section continued its work, although hampered by staff shortages – by 1945 the Monthly Records of Meteorological Observations was five years in arrears. Military developments, such as new airports, resulted in numerous requests for climate information. Clarence Boughner, a meteorologist, had joined Connor in the Section in 1934. By 1949-50, when Connor retired, Boughner had taken over its management, and was to continue as an MSC manager with responsibilities for climatology until his retirement about 25 years later. Morley Thomas joined the Section in 1945, and went on to become one of Canada’s best know climatologists, producing over 80 books and other publications.

The material in this section draws heavily on Thomas (2001 and 2001a).

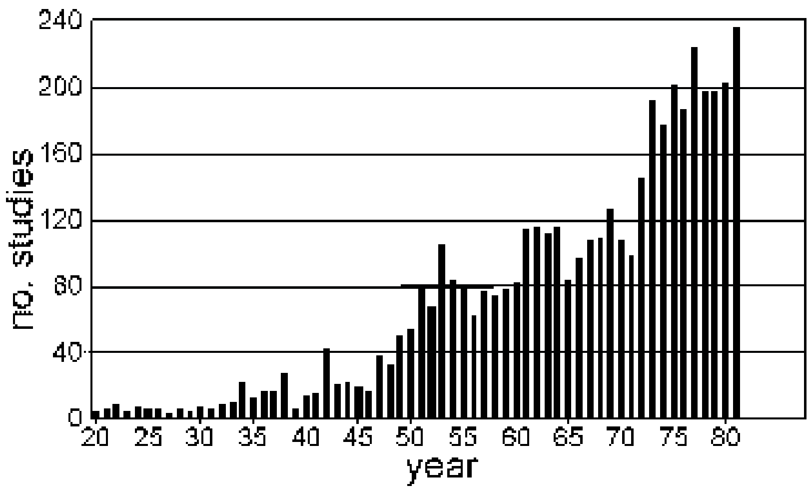
5.2 The post-war increase in climatology

The post-World War II period saw a sharp increase in interest in climatology. For example, Figure 1 illustrates the increase in the number of climate-related studies listed in the *Bibliography of Canadian Climate*. (See Appendix B, Note 2 for more information on this data.) Several factors contributed to this interest.

Post-war years saw an increase in Canadian meteorologists, trained during the war for forecast duties, whose skills were transferable to climatology. Data processing methods also improved, with punch-card processing in the 1950's, mainframe computers in the 1960's and then personal computers in the 1980's. These advances greatly enhanced the climate applications specialist's ability to provide information tailored to specific needs.

Figure 1

Climate Studies in Canada, 1920-81



Starting in the 1960's there was a rapid growth in concern about the environment. For example, Rachel Carson's *Silent Spring,* a landmark in the development of the environmental movement, was published in 1962. The "energy crises" that started in 1973 resulted in rising petroleum prices until the early 1980's. This spurred a search for new energy sources. This included a search for new oil and gas reserves in the Canadian North, and a renewed interest in non-conventional energy sources, e.g. solar and wind. Climate-related considerations were important to the development of these sources, and to the environmental concerns they raised.

Another concern was changes in the earth's temperature. From the 1880's until the early 1940's, temperatures had been increasing. From the latter period until the late 1960's, global temperatures dropped, raising concerns that further cooling would cause major economic dislocation, or even another ice age. These concerns were amplified in the early 1970's, when a series of crop failures in various parts of the world resulted in serious food shortages. By 1980 the results of crude global numeric models had appeared, predicting substantial global warming as a result of increased greenhouse gases in the atmosphere. In the 1980's global warming and its possible impacts grew to become the dominant climate issue.

5.3 MSC response, 1950's to 1970's

5.3.1 The 1950's

At the beginning of the 1950's, climatology at MSC headquarters continued to be concentrated in the Climate Applications Branch (at the time called the Climatology Section), under Clarence Boughner's leadership. Most of the activity continued as previously, with a concentration on climate services rather than climate applications However, in 1950 the Climatology Division started to mechanize the processing of climate data. By 1955 most climate data had been placed on punched cards, and could be analysed using tabulating machines. These machines were the predecessors of computers They provided a considerably enhanced means of analysing data. While their capabilities did not approach those of computers, they greatly facilitated climate applications work. (See Note 1, Appendix B for more information on automation of data processing.)

As demand for climate information increased sharply in the 1950's, MSC responded in two ways. The first was to second MSC staff to other government departments that needed them. (Seconded employees had their salaries paid by MSC, but worked at another agency, usually another part of the federal or provincial governments.) The first secondments were in 1951, with Morley Thomas to the National Research Council's Division of Building Research; and George Robertson and Hugh Cameron to the Departments of Agriculture and Forestry respectively. Seconded climatologists were the responsibility of the Climatology Section and, at least in the early 1950's, reported to Boughner. These postings were to provide a breakthrough for climate applications – see Appendix B, Note 6 for further information on the secondment program and seconded staff.

The second MSC response to increased demand was the formation, at Headquarters in about 1954, of the Special Investigations and Research unit which, as will be discussed in the next section, was a predecessor of AID. It initially consisted of one climatologist, however a 1954 report states that "all members of the Climatology Section are responsible for research and special investigation problems". (The Climatology Section at the time consisted of about 40 people, of which about 7 were climatologists or climate technicians.) In 1957 Hydrometeorology and Micrometeorology units were "being organized", the former at least in part in response to the damage and loss of life (81 dead) Hurricane Hazel had caused in southern Ontario in 1954. The next year saw the addition of an Arctic Climatology unit, although due to staff shortages a manager wasn't appointed until 1960. In 1958 Micrometeorology (subsequently renamed Biometeorology) began field work to study the flecking of tobacco leaves on farms in southern Ontario, a problem that was associated with air pollution. The work was supported by the Federal Department of Agriculture and the Ontario Research Council.

By 1958 the Special Investigations and Research unit had disappeared, however the name was retained to refer to Hydrometeorology, Microclimatology and Arctic. The appointment of seconded climatologists and the expansion of the Climate Applications Branch (by now called the Climatology Division) resulted in a sharp increase in the amount of climate applications work. A list of 1958-59 Special Investigation and Research activities (including Hydrometeorology) provides and interesting insight the type of work being done. A considerable amount of the activity appears to be climate applications.

- A study of evaporation from pans and atmometers
- For stations across Canada, growing degree-days, and monthly fog data
- Meteorological and hydrological aspects of flood control
- Field investigations of snow measurements
- Diurnal variation of dew points and temperatures
- The preparation of a *Bibliography of Canadian Climate*
- Frequencies of wind and cloud-ceiling combinations
- Study of tobacco leaf damage
- Study of the density of newly fallen snow
- Frequency of hourly temperatures to aid in the study of strawberry growth
- Study of heat units for research on soy beans in Ontario
- Wet-bulb temperatures for a design handbook used by commercial organizations
- Study of the duration of high humidity re potato blight in the Maritimes
- Climate trends across Canada

Addition applications work by seconded climatologists included
- Agriculture – better climate networks and better publications for experimental farms
- Forestry – climate on slopes for silviculture and forest regeneration
- Building Research – high wind recurrence and instruments for heat-budget modelling
- Hydrometeorology – flood warning and control for Metro Toronto
- Prairie Farm Rehabilitation Admin. - storm rainfall for dam and reservoir design

5.3.2 The 1960's

The 1960's saw a continued growth in applications work in MSC. By 1961, the Climatology Division had started to take on a resemblance of the Climate Applications Branch it would evolve into by the early 1970's. It was divided into four sections: Operations, Machine Processing, Hydrometeorology, and Climate Research & Special Programs (the latter being a renamed Special Investigations and Research). CRSP included Arctic and Microclimatology. It was to continue with this name through until 1972, when it was renamed Applications and Consultation, and then, later in the 1970's, AID. However until 1966 the heads of the Arctic and Microclimatology units reported directly to Boughner, the head of the Climatology Division, and CRSP appeared to be merely a convenient name for referring to these units. (More information on organizational details from 1954 to 1972 is provided in Appendix D.)

Climatology Division professional staff in 1961-62 are listed in Figure 1a. No information was available on non-professional staff. CRSP had a staff of 3. Six meteorologists were seconded. Of the remaining 10, 3 were in hydrometeorology, 4 were in operations and 2 in machine processing. In general, Meteorologists ("M" in column 2) had MSc's, while Meteorological Officers had BSc's. In 1961 separate staff lists existed for the two groups. In 1962 the lists were merged. By the early 1970's the two groups had been merged.

Fig. 1a - Climatology Division Professional Staff 1961-62

Name	Position Level	Started In MSC	Entered Climatology	Left MSC	Unit
Clarence Boughner	M9	1934	1934	1973	Division Chief
Morley Thomas	M8	1941	1945	1983	Supt., Operations
Rolly Kendall	M5	1942	1951	1973	Operations
Graham Potter	M5	1941	1952	1975	Operations
Robie Titus	M5	1940	1956	1973	Operations
Bev Cudbird	MO8	1940	1948	1978	Supt., Machine processing
John Rogalsky	MO6	1949	1962	1975	Machine processing
Jim Bruce	M6	1948	1955	1985	Hydromet.
Lloyd Richards	M4	1940	1961	1974	Hydromet.
Uli Sporns	MO6	1953	1960	1965	Hydromet.
Harland Thompson	M5	1938	1960	1973	CRSP – Arctic
Eli Mukammal	M5	1956	1958	1984	CRSP - Micromet.
Howard Cork	MO5	1947	1960		CRSP - Micromet.
Seconded					*Agency Seconded to*
George Robertson	M6	1938	1951	1973	Dept. of Agriculture, Ottawa
Les MacHattie	M6	1940	1954		Forestry, Ottawa
Don McMullen	M5	1940		1968	Ont. Dept. of Lands and Forests
Gordon McKay	M5	1943	1959	1984	PFRA, Dept. of Agr.,

					Regina
Don Boyd	M4	1943	1953	c.1980	Div. of Building Research, Ottawa
J.A. Turner	M4				Forestry, Govt. of B.C., Victoria
M = Meteorologist, MO = Meteorological Officer (see text) References: Thomas (2001a), MSC staff lists					

In 1963 another unit, Climate Analysis, was apparently added to CRSP. I use "apparently" because, as in the case of CRSP, it isn't clear whether this was actually a unit with a manager, or simply a convenient label for certain Climatology Division activities.

The following is a list of activities in 1964. Note that it differs from the 1958-59 list given above in that hydrometeorological activities are not included.

Climate Analysis
- climate normals (calculation of 30-year averages of climate elements for Canadian locations)
- aviation weather summaries
- long-term fluctuations in Toronto temperature and precipitation
- climate trends in western Canada
- urban influences on climate

Arctic Climatology
- calculation of normals, averages, and extremes
- duration analyses of sub-zero temperatures, winds and blowing snow
- special studies as requested for Frobisher Bay, Baffin Island, Ungava, and the Mackenzie Delta

Bioclimatology
- lysimeter work (lysimeters measure evaporation - see Section 6.1.5)
- study of the local climate of fruit-tree orchards
- forest microclimate studies at Petawawa (then site of the National Forestry Institute)

The growth of CRSP was aided by the phasing out of the seconded climatologist program, starting in the mid-1960's. By 1972 there was only one remaining secondment, Don Boyd at the National Research Council's Division of Building Research. In 1966 Gordon McKay, who had been a seconded climatologist for seven years with the Prairie Farm Rehabilitation Administration in Regina, became the first manager of AID (with the title Superintendent, Climate Research and Special Programs Section). Gordon's appointment marks the real begin of AID. Since MSC reports start mentioning CRSP in 1961, and its predecessor, Special Investigations and Research in 1954, this assertion is perhaps debatable. But it seems unrealistic to take these earlier dates as AID's beginning.

Bruce Findlay joined AID shortly after Gordon. Both of them had a strong interest in climate applications. Their arrival was the start of a series of staff additions to the Division which would result in another major increase in applications work over the next seven or so years. Gordon worked hard to increase Canadian's awareness of climate issues. He and Morley Thomas (see Figure 1a, and the next section) were Canada's most prolific writers on climatology from the 1950's to the 1980's. The Arctic and Micrometerology units had been headed by Harland Thompson and Eli Mukammal respectively, most if not all the time since their formation. Harland was to continue in this role until 1973, Eli until the early 1980's.

A landmark event in MSC climatology occurred in 1965 when the Climate Applications Branch acquired its first computer, permitting it to provide considerably more sophisticated data processing for its own staff, and for clients. (See Note 1, Appendix B re data processing.)

5.3.3 The 1970's

The late 1960's and early 1970's saw a major expansion of AID. (Staff for selected years in the 1970's are listed in Appendix D, Note 2.) A reorganization in 1972 changed the name of MSC to the Atmospheric Environment Service, a component of the newly created Environment Canada. The Climatology Division, now renamed the Meteorological (subsequently Climate) Applications Branch, became a component of the Central Services Directorate of AES. CRSP was renamed the Applications and Consultation Division, with Gordon McKay remaining in charge, with the title of Chief. The Division was subsequently renamed AID, but to my frustration, I have been unable to determine exactly when.

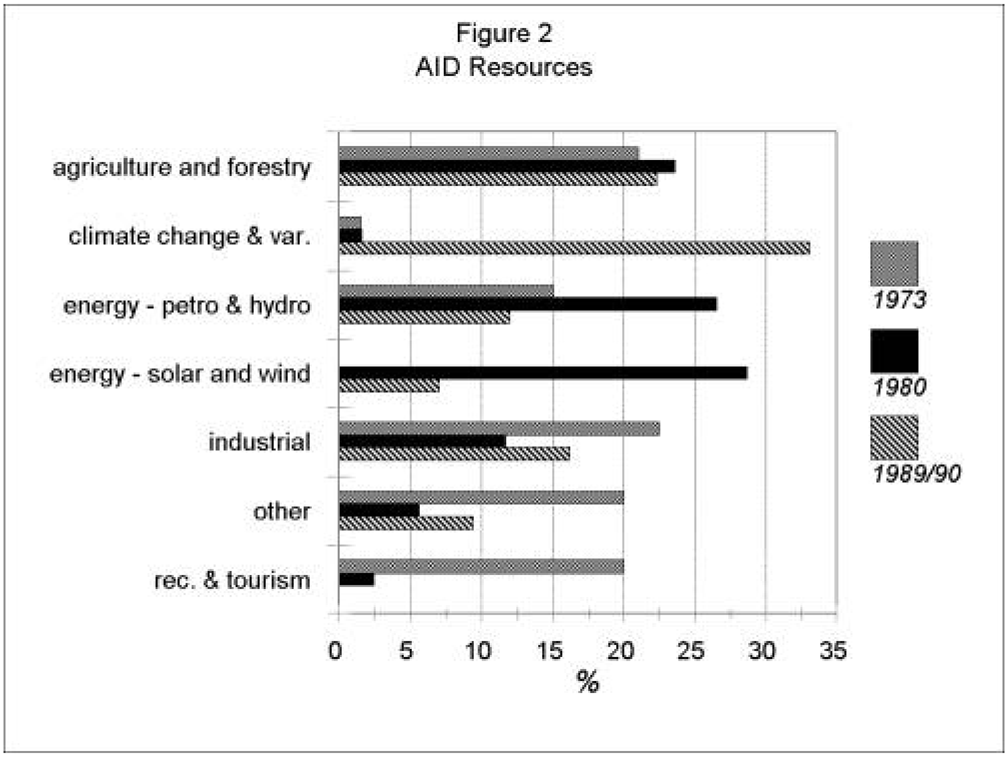
Morley Thomas, who had been Superintendent of Climatology Division Operations since 1953, became Director of CAB, while Clarence Boughner became CSD Director General. Figure 5 provides a list of senior managers from 1973 onward. (Barney Boville, who was in charge of the Canadian Climate Centre for a short period after its creation, is not included in the figure.)

By 1973 AID had the organizational structure similar to the one it was to retain through until the late 1980's - Agriculture, Industrial, Arctic, and Physical Climatology Sections. The Sections were headed by Harland Thompson (Arctic), Bob Verge (E&I), Glen Bristow (Physical), and Rudi Treidl (Agriculture). Biometeorology had been moved to the Atmospheric and Climate Science Directorate (see Section 6.1).

The first half of the 1970's saw the addition of new staff to AID, mostly people in their twenties and thirties - Mal Berry, Ed Birch, Dan Bondy, Bev Burns, Pierre Chaine, Ron Crowe, Joan Masterton, Isaac Savdie, Thorne Won, and others. This influx corresponded to a sharp increase in the amount of climate applications work. Figure 1b gives a staff list for autumn of 1973. (This list is partly derived from AID monthly reports, and may contain errors.) In 1973 the Division had a permanent staff of about 20, close to the number it would maintain through the 1980's. There were about 17 professionals on staff , compared to about 3 in 1961-62, however 5 of the 17 were on temporary assignments or contract. Later in the decade, applications work was given an additional boost by the arrive of substantial funding for energy-related applications work. For example, in 1978–79, AID received $522,000 of supplementary funding for work in this area, the equivalent of about $1.4 million in 2000 dollars.

Fig. 1b – AID Staff, Fall 1973	
Alf Waymann	Technician, Topoclimatolgy
Audrey Clubine	?
Bev Burns	Arctic
Billie Webber (Beattie)	Recreation and tourism (assignment)
Bob Verge	Supt., Industrial Meteorology Section
Bruce Findlay	Topoclimatology
Dan Bondy	Coordinator, James Bay Project (assignment)
Ed Birch	Agriculture
Fred Richardson	Technician, Arctic
Glen Bristow	Supt., Physical Climatology Section
Gordon McKay	Division manager
Harland Thompson	Supt., Arctic Section (retired Nov. '73)
Isaac Savdie	Agriculture (assignment)
J. ("Dan") Roherty	Technician, Industrial
Jim Young	Administrative and technical assistant
Joan Masterton	Recreation and tourism (contract)
Julie Turner	Technician, Industrial
Mal Berry	Arctic
Phil Aber	Management trainee (assignment)
Pierre Chaine	Industrial – ice accretion
Ron Crowe	Recreation and tourism
Roy Woodrow	Arctic
Rudi Treidl	Supt., Agriculture and Forestry Section
Sheila Annis	Secretary

Figure 2 gives an overview of AID activities in 1973, and compares them to those of 1980 and 1989. In 1973, Recreation and Tourism was a major area of endeavour, that would become considerably less important in the 1980's, for a number of reasons, one of which was that much of the work had been completed. In 1973 energy-related applications were growing, but were still considerably less than they would become later in the decade. Work in the agriculture-forestry area was to consume a roughly constant proportion of resources through the 1970's and 1980's. Climate change continued to be of modest interest until the early 1980's. (See Appendix B, Note 4 re the accuracy of this data.)



The following is an incomplete list of 1973 initiatives.

Tourism and recreation

The first volume of the Tourism and Recreation Climate, by Ron Crowe, Gordon McKay and Bill Baker (a consultant) was completed in 1973. Also, about the same time, Bruce Findlay completed the first climate study of a national park. These were AID's first major studies in this subject area and would serve as prototypes for a number of other studies which would be completed between 1974 and 1981. Support for the work came from various government agencies, e.g. the Province of Ontario, Parks Canada, and the (federal) Dept. of Regional Economic Expansion. Joan Masterton and Billie Webber were added to AID around this time to facilitate the work. For more information on tourism and recreation studies see the *Recreational Climate of the National Capital Region.*

Industrial

Much of the work in industrial in 1973 involved studies of ice accumulation on structures, especially towers and power lines. This was to be an area of study that continued through until the 1990's (see *Estimating Icing Amounts Caused by Freezing Precipitation in Canada* for more information.) Work in 1973 was led by Pierre Chaine, and involved field work to set up instruments and collect data, data analysis and modelling. Three papers were produced on the subject in 1973. The other major area of effort in industrial applications was support to aviation, primarily airport climatologies, e.g. wind analysis for a planned new Toronto area (Pickering) airport.

Agriculture and forestry

In the 1970's work in this area primarily involved agriculture, while in the 1980's the emphasis would shift to forestry. Work had begun on a handbook, which was to take 8 years to complete – see *Handbook on Agricultural and Forest Meteorology.* Other work involved development of climate indices in support of corn production, studies of grass minimum temperatures to assist in frost prediction, a pilot study for a soil temperature climatology for Canada, and a study of trends in climate that might affect peach production in southwestern Ontario. At the request of the Canadian Forest Service, a study of the possible climate causes of white-pine disease was also underway.

Energy

In subsequent years a substantial part of AID's efforts would involve support for offshore petroleum development in the Arctic and solar and wind energy. But in 1973 interest was focussed more on providing the climate information needed for the massive James Bay hydroelectric development, and the proposed Mackenzie Valley gas pipeline. Dan Bondy coordinated the James Bay work, with support from various other Division members. Bruce Findlay, Fred Richardson and a contractor, Joe Eley, worked on a study of climate implications of locating pipeline-related facilities at Norman Wells. Arctic Section staff analysed a variety of pipeline-related environmental impact statements. Harland Thompson coordinated the MSC response to the Beaufort Sea Task Force, which was concerned with offshore petroleum development. In 1974 this initiative would result in AID's Arctic Section beginning the first of a series of offshore studies that would continue until the early 1990's.

Other

Other work involved mapping temperatures for North and Central America for a World Meteorological Organization Climate Atlas, and preparing chapters on data and mapping of various parameters for a UNESCO/World Meteorological Organization guidebook. An evaluation of the climate of "Brantridge, Dominica" was done for the Dept. of Transport. Climate estimates were prepared for a new townsite at Resolute Bay, and two other northern sites. Bev Burns and Fred Richardson continued to work on the Climate of the Mackenzie Valley-Beaufort Sea, a comprehensive regional climatology which was completed in 1974. A St. John, N.B., urban climate study, including a special network and mobile studies was also in progress, perhaps for a tourism and recreation study of the region, which was published in 1975. AID staff also provided considerable support to regional climate services units (SSU's/SSD's), which were being established by MSC at the time.

Harland Thompson retired as Arctic Climatology Section Superintendent in 1973, and was replaced shortly thereafter by me. Bob Verge retired from Industrial about 1977, with Thorne Won taking over his duties. In Physical Climatology, Bruce Findlay replaced Glen, who moved on to another job in 1974. Gordon McKay moved from AID Chief to Climate Applications Branch Director in 1976. Howard Ferguson took over as Chief of AID, followed by me in 1978 (see Figure 5).

As another response to the rising interest in climatology, in 1978 MSC was reorganized to create a Canadian Climate Centre (CCC). It combined AID and the rest of the Climate Applications Branch with two divisions concerned with climate research, which were moved from MSC's research group (ACSD). Barney Boville, from ACSD, headed the CCC for a brief period. Morley Thomas replaced him as Director General in 1979.

<u>The Canadian Climate Program</u>

The CCC was designed to be the central component of the Canadian Climate Program, which had also been created in 1978. The intent of the CCP was to promote and facilitate the use of climate information, and to organize cooperation between MSC and other agencies with concerns in the area. About the same time, the United Nations (World Meteorological Organization) created the World Climate Program, with similar aims at the international level. One component of the WCP was the World Climate Applications Program.

Shortly after the formation of the Canadian Climate Program, a series of "sectorial" workshops were held to design the program. These include workshops for agriculture, forestry, energy, building and construction, transportation and tourism & recreation. They brought together individuals from a diversity of government, and to a lesser extend other, organizations. From this process came a large number of recommendations on how climate information could better be used in Canada. These recommendations covered a lot of issues, but many of them fell into the realm of climate applications. A few were frivolous, but most were based on real needs. They formed a basis for a major program. To further this program, a number of committees were established, both subject-specific and region-specific. In the areas of energy and climate change, many of the recommendations were acted upon. In other sectors, many were not. The problem was lack of resources - in the early 1980’s the Federal and other governments began the budget tightening that was to continue, intermittently, into the 1990’s.

These developments certainly increased demands for climate applications and other services. AID, and other parts of the Canadian Climate Centre, had to cope as best they could with these demands, given their limited resources. As far as AID’s budget was concerned, it is difficult in hindsight to judge the Canadian Climate Program’s effects. However the Division did receive large amounts of supplemental funding (see Figure 6), primarily for energy-related work.

6. AID in the 1980's

The Climate Applications Branch, of which AID was a part, also contained a Climate Services Division and a Hydrometeorology & Marine Division. Climate Services was responsible for answering routine requests for information and for routine publications, as discussed in Section 2. AID was responsible for climate applications - providing climate analyses, impacts assessment and advice tailored to meet the needs of specific users. It also was responsible for promoting the use of climate information, for liaison with a variety of other agencies, and for representing Canada at various national and international meetings. In theory, AID's responsibilities did not extent to applications relating to oceans and inland waters, which were Hydrometeorology's responsibility. However in practice, work of the two Divisions overlapped.

The Division was divided into five sections – Arctic, Agriculture & Forestry, Biometeorology, Energy & Industrial, and Physical Climatology (see Figure 3). Biometeorology was more a research than applications unit. In the 1972 reorganization it had been transferred from AID to the Hydrometeorology and Environmental Impacts Research Division (ARQH) of MSC's Research Directorate (ACSD). Staff included Eli Mukammal, Harold Neumann, Denis Walsh and Gary Teeter. It was returned to AID in 1978, by then consisting of two people - Eli and Denis.

Figure 3

Changes in Division Structure and Managers

	1980	1982	1984/03	1984/06	1987	1988	1989
Sections							
Biometeorolgy	E. Mukammal	E. Mukammal	E. Mukammal	x	x	x	x
Physical Clilimatolgy/Cli. Assesment and Impact	B. Findlay	B. Findlay	J. Masterton	B. Findlay	Findlay/Mast.	x	x
Agricultural and Forest Meteorology	R. Treidl	R. Treidl	R. Street	x	x	x	x
Bioclimatology	x	x	x	R. Street	R. Street	J. Masterton	J. Masterton
Arctic Meteorology /Arctic Climatology	B. Maxwell	B. Maxwell	B. Maxwell	B. Maxwell	B. Maxwell	B. Maxwell	B. Maxwell
Energy and Industrial Met./ Industrial Climatology	D. McKay	D. McKay	D. McKay	D. McKay	B. Morris	B. Morris	B. Morris

A list of 1980 AID staff appears in Figure 4. Individuals are grouped to reflect a later organization of the Division, however the column headed "Also in" indicates which of the above-mentioned Sections staff worked in. This figure was assembled from a variety of sources, and probably contain errors and omissions, especially relating to technical staff.

Figure 4 - 1980's AID Staff List

	Year:	80	81	82	82	84	85	86	87	88	89	**Area of Expertise**
	Month:	3	3	3	12	2	4	2	5	10	7	
	Also In											
Arctic Climate												
Andre Lachappelle		X	X									offshore, climate reconstruction
Angus Headley			X	X	X	X	X	X	X	X	X	technical support, various arctic apps.
Barrie Maxwell*		X	X	X	X	X	X	X	X	X	X	various arctic applications, managemen
Dave Etkin	EI					X	X	X	X	X	X	climate change
Jack Emmett		X										technical support
Ralph Harvey				X	X							climatologies, climate change
Stewart Cohen	B							X	X	X	X	climate change impacts
Tom Agnew							X	X	X	X	X	offshore
Walter Skinner	EI								X	X	X	climate change, offshore, industrial
Bioclimate												
Abdel Maarouf								X	X			human and animal
April Hoeller	PC			X	X	X	X					climate change
Bob Paterson									X			human and animal
Bruce Findlay*	PC	X	X	X	X		X	X				various climate apps., management
Dan Williams	AF	X	X	X	X	X	X					agriculture, especially land use
Dave McNichol	PC	X	X	X	X	X	X	X	X	X	X	technical support
Denis Walsh	BM	X	X	X	X	X	?	?				technical support
Don MacIver									X	X	X	forestry, climate change
Ed Birch	AF	X	X	X	X	X	X	X				agriculture
Eli Mukammal*	BM	X	X	X	X	X						biometeorological research
Isaac Savdie								X	X	X	X	agriculture
Janet Isaac										X		technical support
Joan Masterton*	PC	X	X	X	X	X			X	X	X	various climate apps., management
Linda Morsch	PC						X					topoclimatology
Neil Sargent								X	X	X	X	research
Phil Sajecki	AF	X	X	X	X	X	X	X	X	X		technical support
Roger Street	AF	X	X		X	X	X	X	X			forestry, management
Ron Crowe	PC/EI	X	X	X	X	X	X	X	X	X	X	rec. and tour., cli. chg. and cli. reconst.
Rudi Treidl*	AF	X	X	X	X							agriculture, management
Energy and Industrial												
Billie Taylor (Beattie)		X	X	X								building climatology, renewable energy
Bob Beal		X	X									industrial
Bob Morris*				X	X	X	X	X	X	X	X	various E&I, management
Don McKay*		X	X	X	X	X						solar energy, various E&I apps., manag
Heather Auld (89.10)											X	industrial
John Deary					X	X						technical support
Les Welsh						X	?	X	X			ice accretion
Malcolm Geast								X				technical support
Mike Newark						X			X	X	X	industrial, severe weather
Rick Berry		X	X	X								renewable energy
Tom Cutler		X	X	X								industrial applications technician
Tsoi Yip											X	industrial, especially ice accretion
Walter Dnes							X	X	X	X	X	industrial applications technician
Management & Support												
Mal Berry*		X	X	X	X	X	X	X	X	X	X	general climate apps., management
Marilyn Lemaire			X	X	X	X	X	X	X	X	X	secretarial
Lucie Vincent							X	X	X			computer applications
Key												
AF - Agric. & Forestry												
BM - Biometeorolgy												
PC - Physical Climatology												
EI - Energy & Industrial												
* section or div. manager												

Figure 5 indicates the managers (Director General, Director and Division Chief) with responsibility for AID. Barney Boville, who managed the Canadian Climate Centre for a brief period after it's formation, is not included in the figure.

The asterisks in the figure after an individual's name indicate he was an experienced climatologists prior to taking up his management duties. Until the mid-1980's, all managers fell into this category, except for the brief tenures of Campbell and Boville. By 1990, no manager in the figure had this experience. Perhaps there is a trade off in this type of change – senior managers moving in from other areas can bring valuable new ideas, perspectives and management techniques; but they may not have the same understanding of either the science, the functions, or the culture of the group they become responsible for.

Figure 5 - Senior Managers, MSC Headquarters Climatology

Year:	73	75	77	80	82	84	85	87	88	89	90
Month:	1	1	1	3	3	2	4	5	10	7	5
Clarence Boughner	DG										
Larry Campbell		DG									
Morley Thomas	D	D	DG	DG	DG						
Gordon McKay	C	C	D	D	D	DG					
Howard Ferguson			C				DG				
Jim McCulloch								DG			
Kirk Dawson									DG	DG	DG
Mal Berry				C	C	C	C	C	C	C	
Nancy Cutler								D	D	D	D
Dave Colwell											C
Pat Pender							D				
Bill Pugsley						D					

Key
C - Division Chief, AID
D - Branch Director, Meteorological/Climate Applications Branch
DG - Director General, Central Services Directorate/Canadian Climate Centre

To illustrate better what the Division did in the 1980's, its activities are described in the following sections for two years, 1980 and 1989. More detailed profiles of a variety of projects carried out in these two and other years are contained in Appendix A. There remains less information for 1980 than for 1989, hence descriptions of activities, including who did what, is less detailed for the former year. There is a particular shortage of information on technical staff.

6.1 AID in 1980

Figure 2 shows the distribution of resources in the Division in 1980. (See Appendix B, Note 4, for more information on the accuracy of this data.) The majority were about evenly divided between agriculture & forestry, solar & wind energy, and design & operations of arctic offshore petroleum exploration programs. A considerable effort was also underway in industrial applications, for the most part relating to the design of buildings and other structures. Climate change was still a small item in 1980, but grew quickly thereafter.

The appearance of "climate change" as a separate category in Figure 2 may seem odd, since these studies can focus on agriculture, forestry, northern development, etc. However, this distinction is important in following the evolution and eventual fate of AID.

6.1.1 Arctic Climatology

Barrie Maxwell took over as head of this Section in the late 1970's, and continued as an innovative manager with a strong program through to the 1990's. At the time petroleum-related arctic development, and its possible environmental consequences, was the major issue for the Section. It would continue to be a major area of Section work through the 1980's, with substantial funding for it coming from various government programs. The Beaufort Sea, the Arctic Islands, and Baffin Bay were all sites of either operations, or proposed operations. André Lachapelle was the other professional in the Section, while Angus Headley provided technical support.

Offshore petroleum exploration and development

The Climate of Northwestern Baffin Bay is an example of the various studies the Section completed in support of petroleum exploration. A portion of this project was done under contract to Petro Canada, under Barrie's supervision. It provided information needed for design, operation, and environmental assessment of a proposal to drill in the area. A similar study for Lancaster Sound (northwest of Baffin Island) was underway before the end of the year.

Regional climatologies

Barrie completed Volume I of a two-volume *Climatology of the Arctic Islands and Adjacent Waters*. This comprehensive publication was partly in response to petroleum development, but was also intended to serve as a reference for a variety of other individuals and organizations with interests in the area. It was to followed a few years later by *The Climate of the Yukon.* Another publication prepared in 1980 discussed the division of the Canadian Arctic into climate regions.

Environmental Assessment and Review Process

Development in the North fell under the jurisdiction of the Federal Government, which required a rigorous environmental assessment of proposed major developments. This Environmental Assessment and Review process often required extensive climate information. This work consumed a considerable amount of the Section's time, particularly in the review of documents prepared by or for various companies.

Support to other government agencies

The Section also was analysing the distribution of very low temperatures in the North, for Transport Canada, which was concerned about their effects on ship hulls.

Climate change and it's impacts

Climate change associated with increased greenhouse gases was just becoming an issue at this time, however the Section had already started work on the subject, with a literature review, with emphasis on the possible effects of climate change on the sea-ice regime. Interestingly, André Lachapelle, the other climatologist in the Section at the time, visited an organization (Forintek) in Vancouver that did tree-ring analysis, to discuss getting climate information from this source. Presumably, since the North has few long-term weather observing stations, the intent was to attempt to reconstruct past climate variations and trends from trees in those parts of the North where they grew, to better foresee future climate variations. (For more on AID's role in historic climate reconstruction, see "Climate change and it's impacts" in the next Section.)

6.1.2 Physical Climatology

Bruce Findlay headed Physical Climatology for most of the time from 1974 to 1987, except for periods in 1978-79 and 1983-84 when he was on assignment elsewhere in MSC. Bruce was a veteran of AID with an extensive knowledge of climate applications, having joined the Divisions in about 1967. He had done extensive work on the important interpolation problem, which could also be described as Topoclimatology – the study of the variation of climate with terrain. Climate aspects of land-use planning was an important issue at the time. Bruce served as World Meteorological Organization rapporteur on the latter subject, and was a founding member of the Canadian Committee on Ecological Land Classification.

In 1980 Ron Crowe and Joan Masterton were the other professionals in the Division. They had both starting in AID in the early 1970's. Dave McNichol provided technical support. The Section's activities were diverse, and defy simple categorization. The following examples give a fairly representative sample of them.

Climate change and it's impacts

Cynthia Wilson, a contractor, started work on the climate of Hudson Bay during the 19th century. The intent of this study was to reconstruct climate trends back long before modern weather observing programs began. The increasing interest in climate change had brought a realization of the importance of this type of reconstruction, especially in areas like Northern Canada, where conventional records were generally short. In the 1980's AID undertook or supported a number of studies in this area.

For more information, see: *Hudson Bay Summer Season During the 19th Century*

Land-use planning

Joan, Dan Williams and Dave launched a project to develop an objective method to incorporate climate elements into a National Ecological Land Classification System. (A classification system useful for environmental monitoring and land-use planning, e.g. for national parks, forestry. Canadian work in this area gained momentum in the 1970's, and continued through the 1990's – see Marshall and Schut, 1999.) Work in 1980 concentrated on Alberta. Sophisticated statistical techniques were applied to climate and other parameters which had been interpolated to a grid of points 10 km apart.

A second study of the climatic implications of land-use change in Toronto was also underway, by Richard Leduc, Bruce and Dave. Richard worked in AID in about 1979-80 as a temporary employee (project meteorologist).

Support to the recreation and tourism industry

Joan Masterton and Dave McNichol were working on a tourism and recreation study of the Ottawa area, the last of a series of studies that had begun about 1970. For more information see Section 4.3, and *A Recreational Climate of the National Capital Region*. Physical Climatology also prepared an assessment of how the Canadian Climate Program could best provide further aid to the tourism and recreation industry. The report concluded that the most productive area of work would be climate variability studies relating to the feasibility of major developments such as ski resorts. At least one study in this area was later done by Ron Crowe. It concentrated on the effects that climate warming could have on snow cover. (See *Effect of Warming on Snowfall and Snow Season in Southern Ontario*.)

Climate of Canadian Cities series

Ron was preparing the Climate of Ottawa. As well as being a reference on Ottawa climate, this publication was intended as a prototype for climatologies of other cities. Ron continued to coordinate this initiative, with the rest of the series being prepared by regional personnel. (See *Climate of Canadian Cities*.)

Other

Joan Masterton chaired the AES Downsview (Headquarters) Equal Opportunities for Woman Committee. In this period Physical Climatology, and other AID Sections, spent considerable time evaluating "Science Subventions" relating to climate. These were submissions by researchers to the government for grants to support their efforts.

6.1.3 Energy and Industrial Climatology

Don McKay took over Section management from Thorne Won around the end of 1979, and provided strong leadership for the next 4 or 5 years. Bob Beal, Rick Berry and Billie Taylor (Beattie) also worked in the Section. The three of them had joined AID about 1979, although Billie had worked in the Division in 1973 to 1974, before leaving to forecast at the Maritimes Weather Centre for two years, and then to get her MSc Degree.

As in the case of Arctic Climatology, one of the major areas of responsibility of Energy & Industrial was in the support of the development of new energy sources, in this case solar and wind energy. Climate factors were important to both. Much of the work was supported by funding from other government agencies. Industrial Climatology was concerned primarily with design information for the building industry.

Solar energy

A major need of the solar energy industry was a database that combined solar radiation data with a variety of other climate parameters. Development of this database was a major undertaking, particularly because measurements of the required radiation data were not available for most locations across Canada, and hence had to be derived from other information. Completion of this task involved the Section's expertise plus contractors from both universities and the private sector. See *A Merged Solar and Meteorological Data Base* for more details.

Other solar-energy projects involved the assessment of the usefulness of satellite data for measuring radiation, development of improved methods for quality controlling conventionally observed radiation data, and development of a portable instrument for measuring direct solar radiation. A solar hot-water heater had been installed on the roof of the AES Headquarters building. The Section used a number of sensors on the system to monitor its performance in varying weather conditions, and hence gain a better understanding of the effects of climate parameters on the system.

Wind energy

Worked relating to wind energy included a contract to modify the measurements of wind from many observing sites across Canada. Since these measurements were made at varying heights, it was necessary to adjust them to the standard 10-metre level. Data from various levels of a 250-meter tower at Starbuck, Manitoba, were being collected and analysed to better understand how wind varies with height. In addition to helping the standardization process, this information was valuable for estimating winds at higher levels – especially at around 50 metres, the level at which the typical wind turbine operated. Some of this work was cooperative with staff from MSC's research group (ACSD).

Energy consumption

Another initiative was the development of "Population Weighted Degree-Days" for Canada. Degree-Days are calculated from temperature, and are a measure of energy used for space heating of buildings. The objective of this project was to improve the prediction of fuel consumption. The Section also had a contract from Imperial Oil to calculate the occurrence of extremely low temperatures - I'm not sure what the objective of this effort was.

Support to the construction Industry

Industrial meteorology's primary objective was to provide information needed for the design of buildings and other structures. For example, the amount of snow that can collect on a building's roof is an important consideration in its design. Underestimation has resulted in building collapses that have led to loss of life, and major replacement costs. Overestimation can sharply increase construction costs. The amount of ice that can accumulate on structures, especially power lines, must also be accurately determined to prevent structural failure.

Canada's National Building Code contains a section with a variety of different climate parameters such as these. It was the Section's responsibility to derive these values for periodic updates to the Code, and to answer requests from clients in the construction and related industries to provide additional information. Code updates often required extensive work to improve the methodology. The Code work was provided free of charge as a public service. Providing information to specific clients was done on a "cost recovery" basis. (In the perhaps unlikely event the reader is interested in more information on government cost recovery policy as applied in AID, see Appendix B, Note 5.)

In 1980 work started on an update to the wind-pressure data for the NBC. Other work included estimating ice accumulation for four B.C. Hydro sites, and the development of a Building and Construction Workshop, jointly with the National Research Council and the Royal Architectural Institute. A proposal to develop improved methods to estimate ice accumulation was submitted to the Canadian Electrical Association. This was the start of an initiative that would continue into the 1990's. - see *Estimating Icing Amounts Caused by Freezing Precipitation in Canada*.

Climate impacts

Another study, *Mount Saint Helens and Climate Change,* involved assessing the climate implications of the St. Helen's volcano, which erupted in the northwestern United States in 1980. This had been a violent eruption, resulting in concern that it would cause the world's climate to cool temporarily. While this subject would not normally have been of concern to Energy and Industrial, the study was done by Billie Taylor (Beattie), who had worked on the subject for her MSc degree. Billie concluded, correctly as it turned out, that that this particular eruption would not cause significant cooling.

6.1.4 Agriculture and Forest Climatology

Rudi Treidl headed this section from its formation in 1970 until his retirement in 1982. Ed Birch, Roger Street and Dan Williams were also members in 1980. Phil Sajecki provided technical support.

Prairie drought and its effects on agriculture

A major undertaking at the time was the *Prairie Drought Climatology*, a part of a cooperative effort between various government agencies to better understand and prepare for this phenomena, in the wake of a serious prairie drought in 1977. Bruce Findlay, Supt. of Physical Climatology, was the MSC project leader for this initiative. It is included here because much of the supporting working was done by Agriculture and Forest Meteorology Section staff. In 1980 Bruce and Roger Street had a major effort underway to develop the climate-water database essential to the study. Rudi was working on a study of the upper-air patterns associated with drought.

Agricultural potential for land-use planning

Dan William was an expert in assessing the agriculture potential of land, based on climate. He had worked at the Dept. of Agriculture since 1960, first as a seconded MSC climatologist, then as a regular employee, before transferring to AID about 1979. At this time he was working on a method to assess and compare this potential across Canada (see *Measuring Agricultural Productivity as a Function of Climate*). He travelled to Hyderabad to give a paper on the subject at the invitation of the Indian Government, and ICRISAT, an organization promoting improved agriculture methods in arid sub-tropical regions. Dan's expertise was also to be important in determining the impacts of climate on wheat yields for the prairie drought study just mentioned.

Improving climate information – the interpolation problem

One of the most important problems in climate applications is describing the variation in climate parameters between observing sites, which are often located tens or hundreds of kilometres from one another. Not surprisingly, a common theme of the above-mentioned CCP sectorial workshops was the need to address this problem either by taking more observations, or by improving methods to interpolate between existing observing sites.

Many of AID's initiatives had to tackle this problem in one way or another. For example, it was important to the above-mentioned projects in solar energy and offshore climate. In 1980, Agriculture and Forest Meteorology was conducting a literature review of the subject. This was the forerunner of other projects on spatial distribution of climate. For example the *Beaver Valley Topoclimate Study* is an interesting example of this kind of work.

Other

The Section also prepared a set of "ragweed pollen maps". The exact rational for this project is unknown, but it presumably was in aid of allergy sufferers

6.1.5 Biometeorology

Eli Mukammal had headed Biometeorology since its formation in the late 1950's. His primary interests had been research into meteorological factors affecting crop damage from pollution, forest microclimatology, and evaporation measurements. In 1980, with technical support from Denis Walsh, he was working on a study of the damage caused by air pollution (ozone) to white bean crops in southern Ontario. Field work was done to measure ozone concentration levels. A correlation between damage and 10-day averages of ozone was found. As an expert in forest microclimate, Eli was also participating in a study of spruce budworms, pests that were damaging forests in the Maritimes.

Biometeorology operated a weighing lysimeter at a site just north of Toronto. It was a large (10-metres in diameter) container filled with soil, which allowed the measurement of evaporation. It had been installed at considerable expense in the 1960's, "to give us a national and international standard in the measurement of evapotranspiration" (Findlay, 2001). In 1980, data collection was improved with the installation of an new logging system, and a nearby tower for measuring various climate parameters at 3 different heights. Work was underway to abstract current and past data. (See Section 6.2.2 for more on the lysimeter.)

6.2 AID changes, 1981 to 1988

6.2.1 Overview

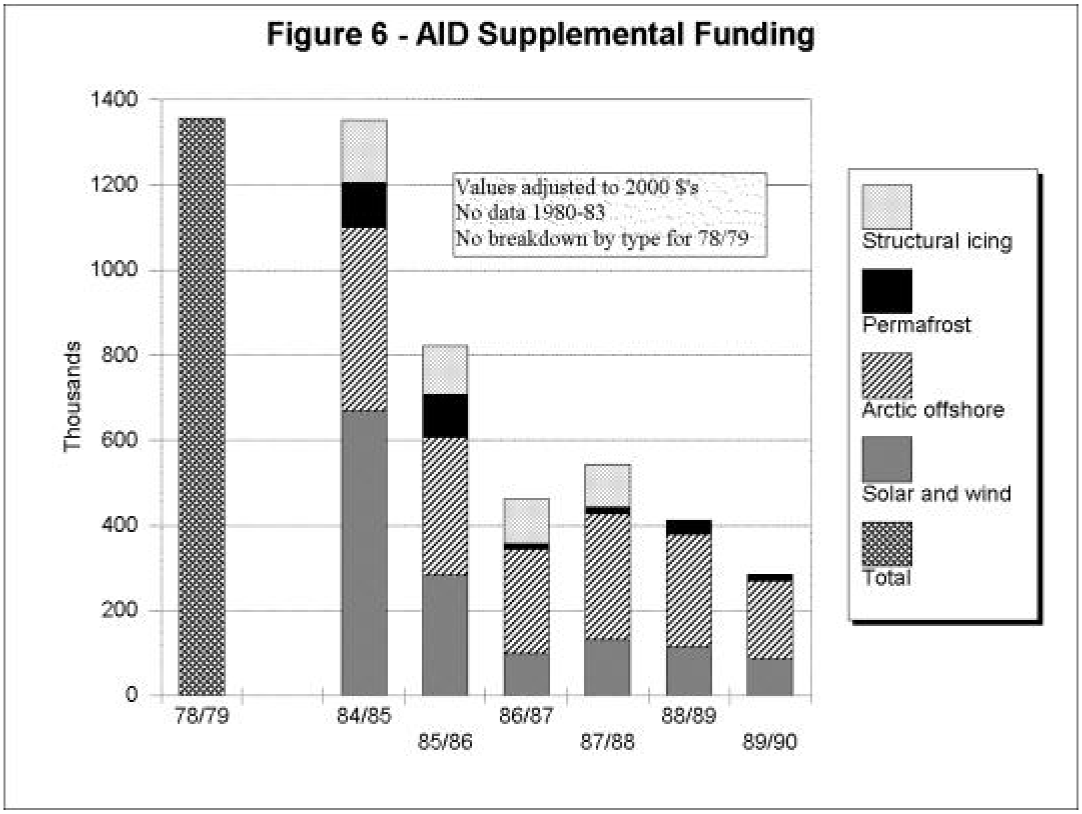
Figures 2 gives an overview of the changes in the Division's program between the beginning and end of the decade. Solar & wind energy programs had decreased sharply by 1989. Offshore related work had decreased by about half. Overall, supplemental funding for energy related programs by 1989 was less than a quarter of what had been received in 1978 and 1984 (Figure 6). The energy programs had been running for more than ten years, and much of the work that needed to be done had been completed. In addition, the "energy crisis" that began in 1973 had abated - crude oil prices that had climbed through the 1970's, to a peak in 1981, had returned to their historic average by 1986, hence government priorities had moved elsewhere. (See Appendix B, Note 7 for more information on Figure 6.)

Industrial Climatology, primarily support to the construction industry, had increased somewhat. The work of updating data for the National Building Code and filling requests from clients for information continued, but in addition there had been an increase in work related to severe weather, especially tornados. Agriculture and forest applications had remained at much the same level, however there had been a sharp increase in emphasis on forestry. The most dramatic change in AID activities was the increase in studies of climate change and its impacts, especially in relation to northern Canada. This was in part in response to a rising interest among clients, but was also an attempt by management to realign activities in view of the fact that the main priority of the Canadian Climate Program had become climate change and its effects.

Figure 4 shows changes in staff over this period. The column headed "Also in" gives more information on which section the individual worked in, i.e. where work was in more than more Section, or where the Section had been renamed or eliminated. Term and student employees have not been included, even though a few of these individuals worked in the Division for extended periods, e.g. Laura Spicer.

In 1980 about half the Division staff worked in what was to become Bioclimatology (i.e. Physical Climatology and Agriculture & Forestry). By 1989 personnel were about evenly divided between Arctic, Bioclimatology and Industrial. The number of people working on agricultural and forestry applications remained about the same. In-house work on climate change relating to the Arctic had expanded considerably, while work in the area of what had been Physical Climatology had been reduced. This does not discredit the earlier work by Physical Climatology. It just means that priorities had changed – for example, Recreation & Tourism and land-use planning no longer had the priorities they had in the 1970's and early 1980's.

The 1985 to 1988 period also saw personal computers come into common use, facilitating the work of the applications specialist. (See Appendix B, Note 1 for more information.)



6.2.2 Staff and organizational changes

Changes in AID organization are indicated in Figure 3. Biometerology was eliminated in 1983, shortly before Eli Mukammal's retirement. The lysimeter (see Section 6.1.5) was dismantled around the same time, when the crown land on which it was located was sold. The operation of a lysimeter was more appropriate to hydrometeorological research than to AID's climate applications program. It had become the responsibility of AID for historic reasons.

Physical Climatology was renamed in 1982. The new name, Climate Assessment and Impact, did not convey much sense of what the Section did, but was deemed more appropriate in a time of rising interest in the impacts of climate change. Agricultural and Forest Meteorology was renamed Bioclimatology in about 1984. Here again, increased interest in climate change impacts was one reason for the name change to Bioclimatology, to accommodate studies on the impacts of climate on humans and wildlife.

Physical Climatology was combined with Agriculture and Forestry in 1987 or early 1988. This change was in recognition of considerable overlap in the activities of the two Sections. It was also a cost saving measure, since one management position was eliminated. Apart from minor name changes, and shifts in emphasis in their programs, Arctic and Industrial Sections remained intact through the 1970's and 1980's.

Bioclimatology

Rudi Treidl retired in 1982, to be replaced by Roger Street. Roger was to provide dynamic leadership to Bioclimatology. The emphasis on forestry applications increased, and stronger links were built with other organizations. Roger had joined the Division about 1980, working in Agriculture and Forestry. Isaac Savdie, who joined the Section in about 1985, maintained an active program of agricultural studies and consultation. Don MacIver joined Bioclimatology in 1987, moving from the Ontario Ministry of Natural Resources, where he had worked in forestry. He continued the strong program in forestry applications that Roger had started. Ron Crowe, who had joined AID in the early 1970's, worked in Physical Climatolgy until his transfer to Energy and Industrial in 1988. He did extensive work in recreation and tourism, urban climatologies, and climate change related studies. Dave McNichol provided Physical Climatology and then Bioclimatology with excellent technical support. Phil Sajecki, a very conscientious and meticulous worker who had been with AID since the 1970's, also provided technical support, first to Agriculture & Forestry, then to Bioclimatology.

Abdel Maarouf joined Bioclimatology in 1985, and revived AID's studies in human and animal climatology, which had been dormant for some time, and which as noted above, had become increasingly important. He left the Division in 1988 for a World Meteorology Organization assignment to Yemen, returning in 1990. Joan replaced Bruce as manager of Physical Climatology in spring of 1987, and then, subsequent to Roger's departure in late 1987, headed Bioclimate. Joan, who had joined AID in the early 1970's, had broad experience in applications work, and brought to the job a strong set of interpersonal skills that were especially valuable in the difficult period that began near the end of the 1980's. Neil Sargent joined Bioclimatology about 1986. His work was more in the realm of research than applications.

Arctic

The Arctic Section staff was stable from the mid-1980's with Barrie, Tom Agnew, Dave Etkin and Angus Headley. They continued the strong programs in offshore and climate change. Tom became an expert in matters relating to arctic offshore climate, while Dave worked on a variety of projects, especially those relating to climate change. In addition to his many other activities, Barrie established a cooperative work program with Russian climatologists.

Angus had been with the Section since the 1970's, providing key technical support, especially field work in the North. Walter Skinner joined the Section in 1986 (he had worked earlier for AID as a student). Walter was a talented and adaptable climatologist, who worked in a variety of areas including climate change impacts, trend analysis, and energy and industrial applications. Stewart Cohen joined the Section about 1986, concentrating on climate change related work. One of his strengths was the ability to build links to the university community, links that formed the basis for multidisciplinary projects which were important for climate change impacts studies.

Energy and Industrial

Bob Morris took over management of the Energy and Industrial Section from Don McKay in 1984 or 1985. Bob had joined the Section about three years earlier. He was an articulate proponent of the role and importance of his Section's activities.   All the 1980 professional staff of the Section - Don, Billie, Rick, and Bob Beal - had left by the mid-1980's. Les Welsh handled, among other things, the ice accretion work in the mid-1980's until his departure in the fall of 1987. Mike Newark joined in the mid-1980's, concentrating on building climatology. Mike was also an expert in severe weather climatology, and expanded the Section's activities in this area. Tsoi Yip and Heather Auld joined the Section in 1989. Tsoi continued the ice accumulation work, while Heather headed building climatology.

Other staff

Lucie Vincent worked part time for AID as a "co-op" student from 1982 to 1984, then as a full-time employee from 1984 until 1988. She provided invaluable computer support to various AID projects. Although a junior employee, Lucie had the skill to assume many of the duties of a senior analyst. Marilyn Lemaire provided secretarial support to the Division for most of the 1980's, making the transition through 4 stages of word processing technology – a manual typewriter, a "smart" typewriter, a dedicated word processor, and finally a PC-based word processor.

Through the 1980's AID had a number of student employees, typically working for four-month terms. Their numbers varied considerably, but probably averaged about three or four at any given time. They contributed a lot to the Division's program, and benefited from the practical experience they gained. To my recollection, Walter Skinner and Lucie Vincent were the only two who moved to permanent jobs in AID. A number of others would have made valuable permanent additions to the Division, however the resources were simply not available to keep them.

6.3 AID in 1989

By the end of 1989 the number of permanent professional staff in AID actually working on climate applications was around 14, about the same as in 1980. In comparison there were about 11 for most of the 1970's, and in the early 1960's, about 3. Total permanent staff was about 19 in 1989. Although totals are incomplete for 1980, it appears that the Division was about the same size.

6.3.1 Arctic Climatology

Work in support of offshore oil and gas development had been underway in the Section since the early 1970's. By 1989, the emphasis of Arctic's work had shifted from the production of design values for offshore projects (e.g. *The Climate of Northwestern Baffin Bay*) to the study of the implications of climate change for both offshore and other activities in the North. This change was accompanied by a decrease in supplementary funding, and an increase in staff, as illustrated in Figures 4 and 6.

Offshore petroleum exploration

By 1989 a *Ice and Snow Climate Information System* (CRISP) was operational, but continued to undergo development under Tom Agnew's leadership. Sea-ice occurrence was an important consideration in northern offshore development work, and in climate change studies. This project capitalized on the new personal computer technology to facilitate easy access to, and analysis of, ice information.

Another computerized system, the Surface Pressure Analysis of System Movements (SPASM), allowed the analysis of historic surface pressure systems (for example pressure patters associated with storms). This system would be of interest to anyone preparing a climatology of pressure systems. Whether it ever became operational, and if so, whether it was ever used for any practical applications work, is unclear.

An analysis of historic storms in the Beaufort Sea, to improve understanding of the characteristics of extreme weather events in the region, was underway. A consulting firm, MacClaren Plansearch, developed a storm analysis system, and used it to analyse a series of storms. This technology was then transferred to AID, giving it the capability to do further analysis.

Climate change and it's impacts

Planning for a five-year *Mackenzie Basin Impacts Study* impacts study was underway, led by Stewart Cohen. This was to be a multi-disciplinary project that would involve participants with diverse research interests, from both government and universities. It was a landmark for AID in that it was the Division's first large-scale, multidisciplinary study of this nature in the climate change area, and would serve as a prototype for future work. Stewart spent a month at the National Centre for Atmospheric Research facilities at Bolder, Colorado to exchange information on climate change impacts work with NCAR's Environmental and Societal Impacts Group. AID staff also provided coordination with members of McMaster University, who were working on a study, supported by AES, on the possible effects of climate change on transportation in the Mackenzie Valley.

The possible impacts of climate change on permafrost had become a concern in the early 1980's. It was feared that melting of ice in the soil would disrupt the ecosystem, and damage buildings and other structures in the North. Starting about 1984, funding was provided to AID by the Panel on Energy Research and Development (PERD) to assess this problem. By 1989 Angus Headley and Dave Etkin had established monitoring stations at four northern sites, and work was in progress on a heat-flow model to better understand the interaction between climate and permafrost. See *Permafrost-Climate Activities* for more details.

The Section was evaluating the usefulness of satellite (SSMI) data for monitoring sea ice. This work would become important to future climate-change related studies.

"Non-standard" data

Much of northern Canada has few weather observing stations, leaving the climate applications specialist with a serious lack of data. For many years the Arctic Section had attempted to address this problem in three ways. One was to collect and archive existing non-standard weather observations, e.g. those made by research parties working in the North. Another was to set up automatic stations, often in cooperation with university or other researchers. A third was to encourage and assist parties visiting the North to make weather observations, for example by providing instruments and training in using them. This work was not strictly speaking climate applications, but was justified on the basis that it provided valuable information needed for northern applications, data that could not be gained without AID's initiative.

Examples of 1989 Arctic Section initiatives on data collection included a workshop on using autostations (unmanned stations) to collect weather data, and development (in cooperation with another Division) of methods to enter autostation data into the National Climate Data Archive. An autostation was installed on the Barnes Ice Cape on Baffin Island, as part of a cooperative project with the University of Windsor.

6.3.2 Industrial

As a result of the decrease in renewable energy activity, the work "Energy" had been dropped from the Section's name. Work related to the construction industry had increased. Two new climatologists, Tsoi Yip and Heather Auld, joined the Section to provide support to this sector. Mike Newark moved from work in support of construction to a new position studying severe weather, a subject he had many years experience with. Severe weather, especially tornadoes, is important to some sectors of industry. It is also of considerable interest to the general public. However, why this Severe Weather position was created in 1989 is now unclear.

Solar and wind energy

At the request of Public Works Canada, the solar energy model previously developed (see *A Merged Solar and Meteorological Data Base*) was being expanded to include information on natural illumination on sloped surfaces, for design of buildings to effectively use daylight. Bob Morris chaired a Canadian Standards Association subcommittee which was preparing guidelines for locating wind turbines.

Support to the construction industry

A report was in preparation on wind pressures, to be included in the Canadian Standards Association standards for the design of antenna and other towers. Maps of snow loads for the National Building Code of Canada were near completion. Improved methods and additional data resulted in average snow loads 6.5% lower than the previous values. It was estimated that this would save the construction industry $46 million. Tsoi, in cooperation with a contractor, COMPUSULT, continued work on ice and wind loads on electrical transmission lines. (For more information on these latter two initiatives, see *Snow Loads* and *Estimating Icing Amounts Caused by Freezing Precipitation in Canada*.)

An automated system for providing clients with information was underdevelopment, designed to operate on personal computers. The system included a computerized database of past transactions, automated preparation of correspondence, and improved management of finances.

Severe weather

This work was in cooperation with AES Regions. Tornado, and other severe weather, data was collected from across the country, compiled into a "common database for severe storms" , analysed, and disseminated, e.g. by publication in the Climatological Journal. A student was hired to update the tornado database, in part to support the Doppler radar network project of MSC's Weather Services Directorate.

Other

Ron Crowe had moved to the Section from Bioclimate in 1987 or 1988. His efforts included reconstructing the temperature record for Toronto back to 1778, which probably provided Canada's only continuous record of daily temperature extending back earlier than the mid-19th Century. He also continued with his responsibilities for the *Climate of Canadian Cities*. Whether he also worked on other projects more relevant to Industrial's objectives seems forgotten.

6.3.3 Bioclimatology

Joan Masterton was managing the Section with Isaac Savdie heading up agroclimatology and Don MacIver leading in forestry applications. Dave McNichol provided technical support.

Forestry applications

Since about 1986, AID had been working in a cooperative project with the Ontario Ministry of Natural Resources to increase the efficiency of tree farms used for reforestation. Under the direction of Roger Street, and subsequently Don MacIver, with the support of Dave McNichol, AID had developed a system to monitor climate parameters at tree farms to permit irrigation at times, and in amounts, that would maximize tree development. By 1989 the SIAMM computer model had been developed to partially automate the system, and AID was in the process of transferring the technology to forestry personnel. See *Irrigation Scheduling in a Seed Orchard Environment*.

Phil Sajecki, along with Roger Street, completed a comparison of winds in a poplar plantation with those of an open site. This was a Ontario Government "farmed forest" site, used to test the feasibility of growing poplars for renewable energy. The relationship between wind at regular observing sites and within forests was poorly understood, even though it was important to a number of applications.

A Bioclimate Profiles project was nearing completion, by Don and Janet Isaac. This provided information of use primarily in forestry and agriculture. Work in 1989 involved writing a users manual, developing display software, and preparing a promotional package for use by the AES Regions. Much of the information included was the same as that in the *Agricultural and Forestry Handbook*, published a decade earlier, although the Profiles presented the data in a more graphical way, and the information was more up-to-date. The stated rational for the publication was to "provide support for the interpretation of biological growth and development processes". As in the case with a number of other AID initiatives, no information is readily available on the extent to which the profiles were used.

Don was also involved as an organizer and proceedings editor in the 10th Annual Fire and Forest Meteorology Conference. He was also in demand on the lecture circuit, giving about a dozen presentations on subjects such as climate change and forests, tree-farm irrigation, and the use of Bioclimate Profiles. He was also appointed the World Meterological Organization's Rapporteur on Operational Applications to Forestry.

The proceedings of *Forest Climate '86* were completed and distributed around mid-year. This conference, jointly sponsored by MSC, the Canadian Forest

Service and the Ontario Government, was organized by Don, Roger and Allan Auclair from CFS. The conference had been attended by a wide variety of individuals with forestry-related interests, and had been of great value in promoting the use of climate and weather information to improve forestry practices.

Applications to agriculture

Isaac Savdie's work included a cooperative effort with AES Regions and Agriculture Canada to improve a weather-based drying index used by farmers, primarily for drying hay. Other work included a study of the use of the TURC index to improve monitoring of crop development, and a study of winter-kill of potato crops on the prairies. Isaac also prepared national maps of climate parameters important to the occurrence of potato blight, a serious problem for farmers, especially in the Maritimes.

The TURC index work brought back Dan Williams, who worked in related areas in AID in the early 1980's, as described in Section 6.1. The index was intended to determine the effects of weather on crop development. Again, it is not clear now how results of this work were eventually used.

Climate change and impacts

Isaac completed a study on *Climate Change and Winter Wheat Yield in Ontario*. This work gives an interesting look at both how global warming could affect agriculture in Canada, and the difficulties encountered in climate change impacts studies.

Discussions were held with University of Toronto staff regarding the establishment a national "focal point" for tree-ring analysis. The primary concern of AID was to facilitate the integration of climate information from the analysis of tree rings from individual sites, to provide a coherent, larger-scale picture of past climate. In conjunction with this initiative, a workshop on the use of tree rings to reconstruct climate was also being planned.

Don MacIver was active in two working groups organized by the Intergovernmental Panel on Climate Change, which was destined to become a very influential organization in shaping world opinion on the importance of the climate-change issue.

Human and animal bioclimate

The Division had a Human and Animal Biometeorologist position in 1989 but work was limited because of the absence of its incumbent, Bob Paterson. However Bill Baker, the consultant who had earlier helped with recreation and tourism studies, did investigate sources and availability of medical and related data regarding climate-human well-being studies. Another project arose from a request from External Affairs to assess the climate of locations around the world where Canadian embassies were located.

Other

Joan Masterton assessed the needs for the Clmatological Applications Branch (to which AID belonged) for Geographical Information Systems. GIS's are computer software for the study of the spatial distribution of climate and other parameters. A system was later acquired and used to develop national maps of climate parameters, with mixed results.

Isaac worked on CLICOM, a World Meteorological Organization sponsored computer system. It was designed to allow developing countries to process and store climate on an ongoing basis, using relatively inexpensive personal computers. He traveled to Niamey, Niger, for about two weeks to do CLICOM installation and training.

7. The Fall of AID

7.1 What happened to AID and its program?

1991 marked the beginning of a series of changes that would dramatically change climatology at MSC Headquarters. In that year AID was dismantled, as was its sister Hydrometeorology and Marine Division. At this point, the three Sections that had comprised AID - Arctic, Bioclimatology and Industrial - were still more or less intact in the Canadian Climate Centre, as part of the newly created Climate Adaptation Branch. However, in 1994 the CCC was disbanded. The Climate Adaptation Branch was moved to the Atmospheric and Climate Science Directorate (ACSD). About the same time a series of job cuts began throughout the Federal Government. For the remnants of AID, this resulted in the elimination of most of the Bioclimate and Arctic programs, except for parts of their climate change related work. Industrial's program was cut by about half. It appears about 70% of what had been AID's program in the late 1980's was cut, although it is difficult to arrive at an exact percentage.

The Climate Adaptation Branch was to become the Adaptation and Impacts Research Branch (AIRB). It was the new centre for study in MSC of the implications of climate change. The group is decentralized, with most of it's staff located at three Canadian Universities. Since its work is interdisciplinary, decentralization is intended to broaden the available knowledge through cooperation with university members. It also provides support to the universities. In 2001 it lists a staff of about 20. The breath of expertise available to AIRB also allows it to better assess the ways society might adapt to climate change. It also permits an integrated look at water and climate resources, while before these responsibilities were split along organizational lines. On the other hand, climate change related work now tends to be fragmented – it's spread out between three universities, some MSC regions, and at least three different parts of ACSD. This is not an insurmountable problem, but it does require effective coordination.

By 1996 five AID alumni - Roger Street, Stewart Cohen, Abdel Maarouf, Dave Etkin and Barrie Maxwell - had joined AIRB. Walter Skinner was also to become associated with the group on a part-time basis. Roger had became the group's Director. In 2001, Joan Masterton and Don MacIver also continued climate change related work, but in another of ACSD's Branches - Science Assessment & Policy Integration. For more information on ex-AID staff, see Appendix C, .

7.2 Why did it happen?

Through the 1960's and 1970's Canadian government spending, especially on social programs, grew rapidly. This growth made it possible for MSC to expand to meet growing demand for climate applications. However, much of the spending was based on borrowed money rather than taxes. A financial crunch was inevitable. Sporadic efforts to tighten budgets had affected MSC through the 1980's. But by the late 1980's the situation had become serious to the point where it was evident that drastic measures could not be long postponed. The recession of 1990 compounded the problem. Shortly thereafter the Federal Government, along with its provincial counterparts, intensified their expenditure reduction efforts. Major social programs were difficult to cut since by their nature they provided their large numbers of beneficiaries with a strong sense of entitlement. MSC programs like climate applications could never develop the same type of support, and hence came under scrutiny.

Serious questioning of the future of climate applications began about 1987. However it was another four years before AID was eliminated, and another three after that before most of the program not directly related to climate change was cut. The following are some the factors that brought application's future under particular scrutiny.

- A "politicising" of the civil service. The organization became more tightly focussed on the immediate needs of its political masters. This was in part, but only in part, a result of tightening budgets. In the case of MSC, this tended to concentrate resources on "hot-button" issues like climate change and air pollution. For climate applications, with the exception of climate change work, the long-time policy of providing "basic" services that benefited a wide range of Canadians was for the most part abandoned. "Special" services, in which clients were charged for work specific to their needs, suffered the same fate, although some capability to serve the construction industry was retained in MSC. (See Appendix B, note 5, for more information on basic and special services.)
- Changes in government priorities. A mainstay of AID's program since the 1970's "energy crises" had been related to the development of new energy sources. By the mid-1980's, energy supply had become a much less important government concern. As a result, the considerable supplemental funding the Division received for these activities sharply declined (see Figure 6). In addition, AID was a victim of its own success. By the early 1990's much of the necessary work relating to energy had been completed. This was also a the case in other applications areas, such as industrial and tourism & recreation.
- Perceived overlap with other government agencies. This was a particular problem with agricultural and forest climatology, since there were other federal and provincial agencies with responsibility in these areas. Up to a point this was a revisiting of the 1960's debate mentioned previously over whether to maintain seconded climatologists in a variety of other government agencies, or to centralize them in MSC. In the 1960's the outcome was to centralize the expertise in a core group in MSC. But in the cost cutting environment of the late 1980's and 1990's, arguments about keeping this core group of expertise were looked at rather differently.
- The difficulty in quantifying the benefits of climate applications. Various

authors, e.g. Phillips (1986), have attempted to identify the benefits of climate applications. The task is difficult, particularly because climate information is typically one of many inputs to an endeavor. While the overall benefits may be identifiable, separating the contribution of the climate input is often difficult or impossible. However, more could have been done. AID was lax, at least in the 1970's and 1980's, in monitoring and documenting the use of its products and services.

7.3 But what about product quality?

When parts of a program like that of AID's is eliminated, it is obvious to enquire about the quality of its products and services. I believe that most of those who knew AID staff, including the Division's clients, would agree that, with few exceptions, they were competent and motivated. Much of the credit goes to Division managers, and the others, who participated in staffing actions to fill AID positions. It was part of my job for over a decade (until 1990) to monitor the quality of AID's output, especially as reflected by clients reaction to it. There were some initiatives whose results left a lot to be desired. But for the most part, quality was good. Client complaints were rare. Peer reviews of the work, for example where papers were submitted to journals, were usually positive.

Since I managed AID, there are grounds to suspect my objectivity on this subject. I have tried hard to be objective - ! have no desire to write a history that lacks credibility. Other than that, I can only suggest that doubters read some of the many reports and papers the Division produced, and draw their own conclusions.

7.4 Was it a bad mistake?

AID's program in the second half of the 1980's involved more than 20 people, with a yearly budget of over $1.5 million. More than half of this was eliminated, including most forestry, arctic, renewable energy, agriculture, and tourism & recreation applications not directly related to climate change. Were these cuts a mistake? To my knowledge no credible assessment of the impacts of the cuts has been undertaken. As a result, any answer to this question must be incomplete.

It seems clear, however, that the government's decision to give priority to climate change related work was the right one. It can be argued that this area of endeavor has resulted in dubious recommendations based more on speculation than science. Whatever the merits of these arguments, they are beside the point. Climate change had become a major international issue in the 1980's, and from a political point of view it was essential that the Federal Government take an activist role.

AID did much on climate change and its impacts. It prepared a variety of studies. Its staff did much to promote the issue. However the current composition of MSC with the Adaptation and Impacts Research Group dedicated to the subject, with its closer ties to university groups, appears to be a better organizational structure to deal with the issue.

AID put much effort into promoting the use of climate information to increase efficiency and effectiveness in various economic sectors. This work did frequently bring benefits much greater than the resources expended. However, by the 1990’s, the Federal Government faced severe consequences if it did not quickly reduce spending. In this situation, it is understandable that this type of activity was curtailed.

AID had made extensive use of the private sector, mainly through contract work. For example, for a number of years, contract work accounted for expenditures varying from a half a million to more than a million dollars annually (adjusted to year 2000 dollars). Private sector consulting firms and universities had gained considerable expertise from this work, as they had from contracts to others, for example studies for the private sector to meet requirements of the Environmental Assessment and Review process. In the absence of AID, some of its work could move to these consultants and universities.

AID staff pioneered many new and innovative methods of applying climatological information to meet Canadian needs. No doubt new issues will arise in the future that will require new approaches. However, much of the methodology developed by AID and its predecessors over more than three decades should form the basis for addressing many future problems, regardless of whether this work is carried out in the private sector, universities, or the public sector.

The question remains, however, whether managers responsible for AID could have more effectively realigned its program to meet changing government priorities. Certainly the increased emphasis on climate change studies was an attempt. Could it have been done better, so as to preserve more of the Division’s program from cuts? This is a “what-if” question to which no definite answer can be given.

Another question involves loss of expertise. The cuts to the AID program meant that a number of individuals with expertise in quite specialized areas of climate applications retired or moved on to other jobs. Many of those who remain in the civil service will likely retire in the next 10 years. Will this leave the government ill-prepared to deal with future climate-related issues, which at present may be completely unforeseen?

7.5 A final word

If any “bad mistake” was associated with the demise of AID, it was probably made by those who felt that its elimination meant that the Division’s efforts had been of little value. Sure, there were some projects that were a dubious use of resources. But the proportion was small. AID managers and staff ensured that the majority of initiatives were well planned and well executed. They met government priorities at the time, and benefited numerous sectors of Canadian society.

Appendix A – AID Project Profiles

List of Projects

The preceding description of AID initiatives focuses on 1980 and 1989, and in most cases provides only a brief mention of individual initiatives. To give a better idea of the Division's work, this section provides a more detailed description of 28 projects completed between 1980 and the 1990's. I have tried to select a sample representative of the Division's efforts in this period. Projects are arranged in roughly chronological order.

1. *A Merged Solar and Meteorological Data Base (McKay et al., 1980)*

The “energy crises” , which started in 1973, and continued to the early 1980’s, spurred interest in non-fossil fuel energy sources. The federal government established a fund to support the development of these sources, including solar and wind energy. The development of solar energy systems required information on the geographic distribution of solar radiation across Canada, to assess whether a system would be viable in a particular location, and if so, its characteristics, e.g. the size of solar panels and their angle relative to the horizontal.

AID undertook the work of developing a database of radiation data, combined with a variety of other climate parameters. The bulk of the work was done under contract, with James F. MacLaren Ltd., Hooper Angus Assoc., and two academics, Dr. John Hayes and Dr. John Davies, participating. The initiative was directed by Don McKay, who acted as the scientific authority. Since solar radiation was measured at only a few sites in Canada, models were needed to estimate values elsewhere. The first task was to compare a variety of mostly semi-empirical radiation models, and determine which was the most suitable. Of the six models tested, the MAC3 model was chosen. Software was developed based on it, and in 1980, a digital database of information was produced for 50 sites across the country.

To determine what this database should contain, questionnaires were sent to 300 people and organizations - researchers, private-sector consultants, other government agencies, and manufactures and installers. Response was good. Based on this input, about 100 elements were included - many of these described cloud cover attributes, but wind, temperature, moisture and pressure elements were also included. Models to calculate radiation on sloped services were also evaluated, and radiation values for surfaces at 30, 60 and 90 degrees to the horizontal were included.

This initiative is an example of a well-executed climate applications project, producing results tuned to the needs of the clients, and well-fitted to government energy objectives.

2. *The Climate of Northwestern Baffin Bay (Maxwell et al., 1980)*

This study, under the leadership of Barrie Maxwell, was done under contract from Petro Canada, which was interested in drilling for oil in Baffin Bay. It was intended to provide information for project design, operations, and the environmental assessment process. It was a joint effort between AID and the Arctic Weather Centre in Edmonton. It was the third of a series of offshore climatologies. The previous two were for the Beaufort Sea and Lancaster Sound.

A key parameters in the study was wind speed, including extreme values. This involved overcoming a problem that is common to many climatological studies, especially in the North - the fact that the site or area of interest is at a distance from where regular weather observations are taken. Two somewhat similar solutions to this problem were used in this study. The first involved estimating the gradient wind (wind at a sufficient height that it is unaffected by local terrain) at a land-based observing site to the northwest of the study area (Resolute) using an empirical relationship, then using this gradient wind to estimate surface winds in Baffin Bay. The second approach involved selecting individual storms, then estimating the surface winds from gradient values using another empirical relationship. In addition to wind information, the study also provided data on temperature, wind chill, ship icing, aircraft icing, sea ice, and waves.

The type of information provided in this report was important to offshore gas and oil development, and the associated environmental review process. Through much of the 1970's and 1980's the Arctic Climate Section acted as a source for an extensive amount of information for these purposes.

3. *Mount Saint Helens and Climate Change (Taylor, 1981)*

The Mount Saint Helens volcano erupted on May 18, 1980 in Washington State, causing a massive landslide that resulted in destruction and flooding as far as 65 km to the west. Within seconds of the start of the landslide, infiltrating water made contact with the underlying, extremely hot, magma. The resulting explosion had the force of about 500 Hiroshima-sized atomic bombs, devastating an area within 20 to 30 km. About 1.5 million animals and birds were killed. Sixty-one people lost their lives. Heavy falls of air-borne ash occurred as far east as Montana, while smaller amounts circled the globe.

Of the many papers and articles I read in preparing this history, this was one of the best written. Billie did an excellent job of describing the volcano, the results of the eruption, and its likely effects on climate. Large volcanoes can alter the world's climate for two or three years, since they place large amounts of ash in the stratosphere, where it persists for a considerable time, reducing the amount of solar radiation reaching the earth. Perhaps the most notable effect of this nature was the 1816 "year without a summer" which resulted from the massive Tambora volcano that erupted in Indonesia the previous year.

Given the spectacular nature of the Saint Helens explosion, there was understandable concern that it too could adversely affect the weather. However, Billie explained that it had injected only about 1 km^2 of ash into the stratosphere, compared to 80 km^2 in the case of Tambora. Consequently its effects on weather were expected to be minimal, a prediction that proved correct.

4. *Handbook on Agricultural and Forest Meteorology (Treidl, 1981)*

This was a three-volume publication by Rudi Treidl, containing in total about 1500 pages. It consisted of 34 tables of climate data for a number of sites across Canada, plus a modest amount of description of the effects of weather on crops. A fair amount of the climate data was already available in other publications, however there were a number of tables which one would be unlikely to find elsewhere, for example information on the number of consecutive days without precipitation for farm operations such as hay drying. This publication was useful in that it brought a large amount of agro-climate material together in one reference.

Work on the project began in 1973. The three volumes were published between 1978 and 1981. Part of the reason the project took 8 years was that it taxed the existing computer facilities. Advice regarding the contents of the publication came primarily from extension works (specialists who advised farmers on weather, climate and other factors affecting their operations), and from university specialists in agroclimatology.

As in the case of a number of other AID products, the extent to which the handbook was used is not clear - it was available in many libraries, both public and institutional, making monitoring of its use difficult. Informal feedback suggested it was a valuable reference for researchers and extension workers. The extent to which it was used by farmers is unknown. The Handbook was published before personal computers and the Internet came into common use. Given the large amount of data it provided, it would now likely be published on either the Internet, or a computer-compatible CD-ROM.

5. *Recreational Climate of the National Capital Region (Masterton, McNichol, 1981)*

This publication completed a series of “tourism and recreation” studies, started in 1973 when Ron Crowe, Gordon McKay and Bill Baker published volume one of the “Tourism and Recreation Climate of Ontario”. Gordon and Bill, a private consultant, had obtained support from various federal and provincial government agencies for these studies, which included publications for the N.W.T., the Maritimes, the Prairies, and Newfoundland & Labrador, as well as studies of several national parks.

Joan Masterton and Dave McNichol undertook this work, which was designed to benefit civic authorities in the Ottawa area, and the tourism and recreation industry. It was also designed to be of interest to the general public. Tourism is an important part of the Ottawa economy. The study was supported by the National Capital Region government, which introduced the results into its planning and operations. This study blended data from MSC’s regular climate observations with data Joan and Dave collected around the NCR from a local network they set up, and from a series of mobile surveys.

Based on a variety of climate parameters, they defined “Activity Days” - for example, the average number of days per year suitable for vigorous outdoor activities (153), passive activity (134), beach activity (92), skiing (99) and snowmobiling (98). The distribution of these days through the year was illustrated. Climate parameters such as hours of sunshine, wind-chill and humidex were described. Climate aspects of such things as snow making and “Alpine snow trail grooming” were also included. The publication is 120 pages long, and sold for $9.00 when released.

6. *The Climate of the Arctic Islands and Adjacent Waters (Maxwell, 1982)*

This publication, completed by Barrie Maxwell in 1982, was the second of three climate reference books published by AID for northern Canada from the mid-1970’s to the mid-1980’s. *The Climate of the Mackenzie Valley - Beaufort Sea,* by Bev Burns, was finished in 1974. In 1987 Herb Wahl (MSC Whitehorse), Dave Fraser (MSC Edmonton), Ralph Harvey and Barrie completed the *Climate of Yukon*.

The primary motivation for the Arctic Islands and Beaufort Sea publications was planned oil and gas exploration and development. Areas where offshore exploration was either underway or planned in the 1970’s included The Beaufort Sea, Lancaster Sound and Baffin Bay. A pipeline was planned for the Mackenzie Valley (until a 1977 moratorium). A late-1970’s plan, The Arctic Pilot Project, envisioned shipping natural gas by tanker from various sites in the Arctic Islands. These developments required considerable amounts of climate information both for design and for the Environmental Assessment and Review Process. EARP, a Federal Government responsibility, required extensive assessment of the environmental implications of proposed developments in northern Canada. However, these publications were not intended only for activities related to oil and gas development - the severity of northern climate made it an important consideration in a variety of other endeavours. Another reason for these publications was to provide readily available reference material that would reduce the number of requests to MSC for climate information.

The Arctic Islands climatology was comprehensive - consisting of two volumes, and a total of about 1100 pages. It reflect Barrie’s extensive knowledge of the subject. It contained a wide variety of maps and tables, and some discussion intended to give the reader a basic understanding of the nature of climate in the Arctic. For example the importance of “climate controls” such as solar radiation and terrain effects was discussed.   When released, the two Arctic Islands volumes were priced at $35 and $42. Reference books of this nature were labour-intensive at the time, involving considerable effort by climatologists, technicians, cartographers and secretaries. (With the subsequent arrival of personal computers and better analysis software, a fair amount of the work was automated.) I don’t know exactly the extent to which sales recovered production costs, but all costs weren’t recovered.   However, this wasn’t expected. There was a serious need for the information in these publications, and it was considered the government’s responsibility to provide it.

7. *The Climate of Arctic Canada in a Two Times CO2 World (Harvey, 1982)*

This was one of the early climate change studies undertaken by AID. It was done at a time when considerable interest in the subject had developed, but there was little information available about what might happen in Canada’s North

The changes used in this study were intended to represent conditions with the earth's atmosphere having twice the concentration of greenhouse gases of the pre-industrial era. Contemporary numeric (global circulation) models (e.g. Manabe and Wetherald, 1980) only produced results in the form of surface temperature changes averaged by latitude. This output provided little information about regional changes. Analogue techniques, which extrapolated past changes into the future, provided more detail, although their applicability to future climate change scenarios was uncertain. Ralph used this analogue approach to provide a first detailed estimate of how Northern Canada's climate might change.
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It is debatable whether this study, by itself, is climate applications or research. Other parts of AID's application program needed the information, it wasn't available, hence it was judged appropriate to undertake the work.

Ralph started the study with a good discussion of past climate trends and atmospheric circulation patterns. He then derived two sets of warming patterns by taking differences between contemporary patterns and estimated patterns from two historic periods - a warm one (the Climatic Optimum, about 5000 years ago) and a cold one (about 20,000 years ago). From these changes, projected surface temperature changes were deduced from upper-air patterns. Also there is some discussion of possible changes in precipitation and sea ice.

The changes in temperature patterns look plausible, compared to the observed patterns of warming that occurred in the decades up until 2000. This work was speculative in nature, but this was, and still is, typical of most climate change work.

8. International Cooperation on Arctic Issues (Maxwell, 1983-96)

In 1983 two members of the Arctic and Antarctic Research Institute in St. Petersburg visited AID to discuss Russian-Canadian cooperation in arctic climate projects. Subsequently, AID proposed several joint initiatives under a new cooperative program in areas related to data exchange, climate change and weather system typing. Several visits back and forth between staff from AAIR and AID's Arctic Section resulted, with the exchange of a variety of data and expertise. At least one scientific paper was written. The exchange lost steam as political events overtook Russia at the end of the decade.

The opportunities to access Russian data and interact with Russian scientists prompted the Arctic Section to broaden its contacts with other arctic countries. For example, in 1991 contact was made with the newly formed International Arctic Science Committee (IASC). IASC was beginning to develop interest in the climate change issue and through its then President, Fred Roots, asked the Arctic Section to provide advice with respect to climate change impact issues. Barrie Maxwell served on IASC's Climate Change sub-committee and was instrumental in having IASC eventually initiate regional integrated impact studies for the Barents and Bering Sea areas, using the Arctic

Section's *Mackenzie Basin Impact Study* as a prototype. He was subsequently asked to represent Canada on the IASC Council beginning in 1994, and was later elected a Vice President.

This description is based on Maxwell (2002).

9. Measuring Agricultural Productivity as a Function of Climate (Williams, 1983)

Based on wheat-yield data, and using empirical methods, Dan Williams developed relationships between climate factors and agricultural productivity. The length of the frost-free season, and the ratio of rainfall to plant evaporation, were the determining factors, although modifications had to be made in locations near coasts.

The original reason for developing this index (in the 1970's) was for land-use planning, e.g. to help assess whether land was suitable for agriculture, which was an important issue at the time. But the expertise developed was to provide useful for other purposes, e.g. the Prairie Drought Study (see below), and in assessing the effects of climate change

10. The Costs and Benefits of Inclement Winter Weather in Toronto (Rowe, 1984)

This is an interesting study of the economic costs of snow on a major urban area. Kevin Rowe, an economics student, was hired for the summer of 1983 by the Physical Climatology Section, under what was then known as the Career Orientated Program for university students. He studied the impacts of snowfall in Toronto for two winters, 1981-82 and 1982-83. The former winter had much more snow than the latter. He analysed snow removal costs, and developed a way to estimate the extent to which winter weather driving conditions were reflected in expenditures in auto-body repair shops. He concluded that snow removal costs (not including the private sector) were $57 million and $47 million respectively in these two winters, and that weather-related auto expenditures from accidents were $11 million and $6 million. The costs of repairing auto corrosion caused primarily by winter road salting were estimated at $21 million for each of the two years.

He recommended that costs of snow control and corrosion repair could be reduced by better use of weather information in snow-control activity. He also recommended study of the cost effectiveness of fixed as compared to on-demand snow removal contracts.

I believe this study was done in support of a MSC initiative at the time to demonstrate the economic impacts of weather and climate – to help justify its budget. The work also provided a basis for assessing the economic effects of climate change, however it appears that Rowe completed it just before climate change predictions for Ontario became sufficiently detailed to be used for this kind of assessment.

11. Effect of Warming on Snowfall and Snow Season in Southern Ontario (Crowe, 1985)

This study, by Ron Crowe, estimated that greenhouse-gas induced warming could have serious effects on the availability of snow, and by implication the skiing industry, in southern Ontario.

By the mid-1980's, numeric model predictions of climate change had improved considerably over those available to Harvey for his 1982 arctic climate change study (see above). Ron had available monthly predictions of temperature and precipitation changes on grids with spacing of roughly 500 km (from the GISS and GFDL climate model outputs for doubled atmospheric greenhouse gas concentrations). This information, plus contemporary climate data, was transferred to grid points covering southern Ontario at approximately 50-km intervals. The predicted values were compared to current conditions, permitting calculation of the changes in the occurrence of snow, and the duration of snow cover.

The predicted values include only total precipitation, so Ron derived relationships to estimate snowfall from temperature and precipitation. Using a definition of continuous snow cover from AID's tourism and recreation studies, he then calculated the predicted number of weeks of continuous snow cover, some of which are tabulated below. Areas which receive large amounts of snow, like South Georgian Bay, had considerably smaller reductions in the duration of snow cover than did other regions. In more southerly areas, predicted losses of eleven or more weeks of snow cover effectively reduce average durations of cover to periods of less than a week.

In common with other climate change impacts studies, the results of this effort must be considered as speculative. In addition to the uncertainties in the predictions of circulation models themselves, they provide data on a much coarser scale than used here. Also, the predicted values were only available as monthly averages, a frequency which placed limitations on the accuracy of studies of this nature.

However, while the specific figures tabulated below should not be taken too literally, they do indicate, for example, that some southern Ontario ski-resort operators could be seriously affected by greenhouse warming, and that the hydrological cycle in the region could be significantly altered, e.g. with less moisture available in the spring. This study demonstrates what a talented climatologist could do, given existing limitations of methodology and of quality of data.

Effects of Climate Warming on Duration of Snow Cover (in weeks)

	Hamilton	Kingston	South Georgian Bay	Peter-borough	Ottawa
Present	0	11	15	11	15
GISS Scenario	0	0	13	3	11
GFDL Scenario	0	0	11	0	8

12. Past Climate Change in the Canadian Arctic (Maxwell et al., 1985)

This is one of several initiatives taken by AID to study how future climate could vary and change, by studying past climate, using both instrumental records and proxy climatic data. (For more information on this subject, see the *Hudson Bay Summer Season During the 19th Century,* below.) The nature of these future climate variations is an important consideration in a number of northern development and environmental issues, particularly in relation to sea ice and permafrost.

Past Climate Change in the Canadian Arctic gives a good overview of this subject. It was prepared by Acres Consulting Services Ltd. under Barrie's direction. Funding was provided by the Panel on Energy Research and Development. It looked at climate changes on two time scales - 0 to 10,000 years ago, and 10,000 to 150,000 years in the past. It draws on a broad range of sources for insight into past climate, for example glacier cores, sea level, plants, archaeology, and tree rings. There is a good review of the literature, and a good presentation of results. It appears to be comprehensive. It suffers from a lack of quantitative results, but this reflects a problem with the available data. The authors point out that other countries, like Scotland and Russia, have a much larger supply of data to draw on.

13. Prairie Drought Climatology (Findlay, Williams, Street, Treidl, et al. 1986)

A serious prairie drought in 1977 alerted governments to the need to better understand the phenomenon, and to develop better ways of coping with the resulting impacts, primarily on farming. As a result an inter-agency drought study was launched. Bruce Findlay was appointed leader for MSC's part of the project. In 1981, with Roger Street, he completed the major task of preparing a database of water balance values at 10-day intervals between 1925 and 1980, for 219 grid points across the prairies. (Water balance provides an indicator of the amount of moisture in the soil, taking into account precipitation, evaporation, and surface and sub-surface motion of water.)

In 1986, this work had been extended by Rudi Treidl to discuss weather patterns connected to drought, and by Dan Williams to estimate wheat yields for the grid points, using regression analysis (a statistical technique commonly used by climatologists and others). Williams also estimated dollar values of annual losses resulting from reduced crop yields caused by drought. Members of MSC outside of AID also contributed to the study.

Since it is not possible to forecast the frequency of droughts in future years by using conventional weather forecasting techniques, this climatological analysis provided a statistical expectation of what will occur in the future, separating the effects of weather on crop yield from other influences, such as crop disease, changes in farming methods and government crop support programs. In addition to providing information on the future frequency of occurrence of drought, this approach gave a more detailed understanding of its nature - how it originates and spreads, and its duration. It also improved understanding of the links between local and large-scale weather patterns, links that can provide useful for shorter-term drought monitoring and prediction.

The successful completion of this study required considerable expertise in climatology, and in the relationship between climate and other parts of the environment, e.g. hydrology and crop development. The work provided an important reference on the nature of occurrence of drought for other parts of this inter-agency project. Other AID participants in the study included Ed Birch, Ron Crowe and Phil Sajecki.

14. Forest Climate ‘86 (MacIver, Street, AuClair, 1986)

A responsibility of AID was to promote the use of climate information in various sectors of Canadian society, in order to increase efficiency and to minimize adverse environmental effects. Forest Climate ’86 was a good example of this kind of initiative.

While there had been some work in forest climatology earlier, it was in 1982 that a vigorous program developed under the leadership of Roger Street. A hallmark of the program was its close ties to The Canadian Forest Service, and to provincial forestry departments. AID effectively promoted the use of weather and climate information in forest research, planning, and operations. To this end, Forest Climate ‘86 brought together individuals from across Canada with interests in a variety of aspects of forestry. It was jointly organized by Roger, Don MacIver of the Ontario Ministry of Natural Resources (who would soon transfer to AID), and by Allan Auclair of CFS. MSC, CFS and OMNR jointly sponsored the function.

It was held at Geneva Park, near Orillia, Ont. About 46 papers and 15 posters were presented, discussing climate and weather applications to subjects such as seedling production, operational procedures (e.g. thinning and fertilization), fire weather, air pollution effects, and the potential effects of climate change. The proceedings were published as the book *Climate Applications in Forest Renewal and Forest Productivity.*

15. Beaver Valley Topoclimate Study (Findlay, 1986)

The intent of this study was to address a common problem in climate applications. Since climate varies with distance and the underlying terrain, and since observations in most areas are only made at sites tens or hundreds of kilometres apart, it's often necessary to interpolate values to the area of interest. Accurate interpolation is often not a simple task. The intent of the Beaver Valley study was to facilitate this task by developing a better understanding of the variation of climate with terrain, based on observations from a network of temporary sites set up for the purpose. The results would then be generalized to develop improved interpolation techniques that could be used elsewhere.

Beaver Valley opens northward to Georgian Bay, near Collingwood. The study area was about 250 sq. km. in the northern part of the valley, where elevations vary by about 200 m. One MSC climate observing station was present in this area, and to it was added a network of five automatic stations, which measured temperature, humidity and wind, at hourly intervals. Measurements of snow density were also made. Data was collected, using mostly automated instruments, from Sept. 1984 to May of 1986.

The objectives of this study were good, and the results produced were useful. However, the work would have been more valuable if more had been done to generalize the results for use in other locales. Unfortunately, because of staff changes and other reasons, work on the project had to be ended prematurely.

16. Commission for Agricultural Meteorology (Berry, 1979-86)

Since climate applications require much interaction with clients, AID members spent a substantial part of their time at meetings and conferences, and were active members of a variety of working groups, committees, etc. Unfortunately, apart from papers published in conference proceedings, most information about these activities is lost, or at least not readily available to me, hence there is little mention of them in this history. AID's participation in the Commission for Agricultural Meteorology is one exception to this shortage of information, since I served as Canada's principal delegate for its three sessions held between 1979 and 1986.

CAgM is a United Nations agency that promotes the use of weather and climate information in support of agriculture, forestry and fisheries, especially to improve production in developing countries. Delegates from about 60 countries meet about every four years to plan the Commission's program. Between sessions, approximately 14 working groups and rapporteurs (one-person working groups) work on a variety of matters, supported by a secretariat in Geneva.

Prior to each session, delegates are sent the reports of the various working groups and rapporteurs, along with a host of position papers (there were 42 in 1986), which usually propose future activities. This information must be digested, comments sought from experts across Canada on the various subjects discussed, then analyses of each of the CAgM position papers prepared. Where an issue is of concern to Canada, these analyses included a proposed Canadian position. The two-week sessions were busy times. In addition to the all-day meetings, many evenings and parts of weekends involved meetings, and reading and writing a seemingly endless number of new and revised position papers.

Apart from the formal work of the Commission, its meetings gave participants a chance to discuss mutual concerns with members of foreign meteorological services whom they would otherwise never meet. It was also gratifying to be able to have a modest influence on an international program. For example, it was apparent at the 1979 session that a number of developed countries were losing interest in CAgM because of its almost exclusive focus on farming methods in developing countries. The Canadian delegation did have some success in expanding this focus to include other problems considered pressing at the time, for example those relating to declining forests, and the effects of air pollution on crops.

17. An Ice and Snow Climate Information System (CRISP) (Agnew, 1987)

This computerized system was designed primarily to provide sea-ice data "for engineering design, planning and policy development." It was one of the first projects in AID to utilize the personal computer . The primary intent was to address the needs of offshore oil and gas exploration and development, and the related environmental impact assessment process. Most of this offshore exploration was conducted in areas where sea ice was present much of the year, and where it placed serious constraints on activities. However the information that CRISP could produce was also of use in other applications, for example, detecting trends in sea ice for climate change studies. The project was supported by funding from the Panel for Energy Research and Development (PERD). Tom Agnew led it, with work done under contract by a consulting firm, Canadian Systems Group.

The project permitted analysis of ice data for a wide geographic area, based on data collected by MSC's Ice Centre, and U.S. Government civilian and military agencies. U.S. data was for 1972 to 1984, Canadian data for varying period between 1959 and 1984. Nearly 20 years of snow-cover data, and degree-day data (based on accumulated temperatures) were also included. The intent of the project was to allow easy access to this information from personal computers. It allowed analysis of freeze-up, break-up, the amount of water covered, and type of ice for selected geographical areas and time periods. Information could be produced in the form of maps, time series, and tabulations. As of 1987, it was planned to add iceberg and ice motion data.

It may seem odd that PERD provided funding for this project to AID, rather than MSC's Ice Centre. However the Centre was primarily orientated toward operational ice monitoring. AID had the required expertise to plan and develop the system. Some credit must go to AID's sister division, The Hydrometeorology and Marine Division, which had already developed a marine climate information system (the Marine Statistics Package, MAST). The development of CRISP benefited from MAST technology.

18. Marine Climate Atlas, Canadian Beaufort Sea (Agnew, Spicer, Maxwell, 1987)

Looking back now, there appears to have been some justification problem with this project. The stated, rather tenuous, reason for it was a local newspaper report of an announcement by Gulf Oil Corp. of a plan to develop the Amauligak oil and gas field in the Beaufort Sea. Also, it failed to make any reference to the Beaufort Sea climatology AID had already completed (in cooperation with the Hydrometeorology and Marine Division, and the Arctic Weather Centre) in 1975.

From a scientific point of view, this project seems to have been justified. A considerable amount of additional offshore observations had accumulated since the 1975 study. Analytical techniques had improved. Given the technology available, and the fact that Tom Agnew had participated in the development of a similar publication for the East Coast, the amount of work involved in this project should not have been particularly large. At the time oil prices had tumbled from their 1981 peak. However, I believe it was not until a couple of years later that interest in Beaufort Sea oil and gas waned, and Gulf scrapped the Amauligak project.

The MAST/CRISP family of data tools (see above, “An Ice and Snow Climate Information System”) was used to partially automate preparation of the publication. Parameters included were sea ice, wind, temperature, sea temperature, ceilings and visibility, surface pressure, atmospheric icing, and precipitation. The maps included did improve the presentation of the data, compared to the 1975 study.

19. Hudson Bay Summer Season During the 19th Century (Wilson, 1981-88)

Reconstruction of past climate is important to climate change studies. For example, estimations of future change in the earth’s temperature are based to a large degree on the results of numerical modelling of future conditions. These models provide simulations of future events, but are of limited value without supporting evidence of historic variations and trends. An understanding of past climate is also useful to other applications not directly related to climate change, for example estimation of the likely frequency of prairie drought or other severe climate events.

AID gave considerable support to the National Museum of Natural Sciences’ Canadian Committee on Climate Fluctuations and Man, which provided a forum for reporting on, and coordinating, historic climate studies. The Division also undertook or supported a number of studies to reconstruct past climates based on either old conventional weather observations, or proxy data. (Proxy data refers to climate information that can be derived from tree rings, glacier characteristics, lake bed sediments and other materials.)

It’s debatable whether these activities fell into the realm of climate research or applications. The rational for AID’s involvement was that an understanding of variations and trends in past climate would benefit a number of applications studies. Also, historic climate studies tend to be site specific. A long-term goal of AID was to integrate the information from these studies to produce a coherent picture of past climate in Canada.

This Hudson Bay study was prepared under contract by Cynthia Wilson, with project management by Bruce Findlay. Published in 4 volumes, it reconstructed summer temperature and precipitation for most of the 19^{th} Century on the east coast of Hudson Bay. The reconstruction was based on a mixture of instrumental records and proxy data, gleaned from Hudson Bay trading post records. These records include a variety of information on weather conditions, freeze-up and break-up, crop growth, and a variety of other indicators of weather conditions.

Cynthia's work provided valuable information on past climate in a part of Canada where this information was sparse. In addition, it provided a significant advance in the methodology needed to utilize early instrumental records, and proxy data of the type gathered by traders and other pioneers. It also showed that this type of reconstruction was labour intensive.

20. Residential Gas Consumption Over the Next Fifty Years (Findlay, Spicer, 1988)

Bruce Findlay and Laura Spicer prepared this interesting look at what might be the effects of climate warming on natural gas consumption for space heating in Canada. The approach was similar to Crowe's study of the effects of warming on the snow cover of southern Ontario (see above), to the extent that it was based on two sets of temperature predictions (from the GISS and GFDL global climate models) for a world in which atmospheric greenhouse gas concentrations are double the pre-industrial levels.

They found a good correlation between gas consumption and an index that could be calculated from monthly temperatures. From this they calculated the decrease per customer in gas use, which for Ontario was 14.2% or 25%, and nationally 9.3% or 16.7%, depending on which temperature prediction was used. They also obtained population projections for the year 2031, and from those were able to calculate the change in total consumption for space heating, under the assumption that heating technology did not change.

This study must be viewed with the caveats previously mentioned for climate change impact studies, but it provided a nicely done scenario of what most would consider a positive effect of climate warming.

21. Climate of Canadian Cities (Crowe, 1983-89)

In 1983 Ron Crowe prepared the Climate of Ottawa, an inexpensive publication on the city's climate, intended for a general audience. As well as a reference on Ottawa's climate and weather, it was intended as a prototype that Environment Canada regional staff could use in preparing other city climatologies. Between 1983 and 1989 these were prepared for Edmonton, Calgary, Montreal and Toronto, with advise and support from Ron and other MSC Headquarters staff.

Each was tailored to local interests, but most included information on such things as human comfort (wind chill and humidex), frost-free days for gardening, the range of high and low temperatures at different times of the year, and weather-related extreme events such as floods and unusually heavy snowfalls. Prices ranged from $3.50 to $8.00.

22. *Permafrost-Climate Activities (Etkin, Headley, 1984-1988)*

Permafrost (permanently frozen ground) underlies much of northern Canada. Changes in the permafrost regime can have major effects on the soil, vegetation cover, buildings and other structures. The distribution of permafrost is sensitive to air temperature and to other climate parameters such as snow cover, however these relationships were poorly understood. As a result of the growing concern about the possible effects of climate warming on permafrost, AID proposed to the Panel on Energy Research and Development (PERD, managed by the Dept. of Energy, Mines and Resources), that a contractor be hired to take an initial look at this matter, and if warranted, propose initiatives to assess the problem. Presumably PERD was concerned about this primarily because of the effects that changes in the permafrost regime could have on proposed gas and oil pipelines, particularly in the Mackenzie Valley and Yukon.

Hardy Associates Ltd. completed a report in 1984 recommending that several stations be established in the North to collect data that would help in the understanding of climate-permafrost relationships.   In addition, the development of a empirical model of these relationships was proposed, in conjunction with the development of a numeric heat-flow model. Automated climate data collection systems were established at Mayo, Norman Wells, Churchill, and Schefferville, using Campbell Scientific data loggers. A number of problems were encountered, and overcome - a tower used for wind measurement was stolen, tape cassettes used to record data would not work because of the extreme cold, conventional batteries had to be replaced by a combination of solar panels and rechargeable batteries, and the logging system at one station had to be buried underground for protection from the weather.

The intent was to continue the data collection for at least ten years. As of 1988, work was in progress on the heat flow model.

23. *Climate Change and Winter Wheat Yields in Ontario (Savdie, 1989)*

To assess the possible effects of greenhouse gas induced climate change, Isaac started with 30 years of climate and winter wheat-yield data for southern Ontario. Winter wheat, which is planted in the fall and harvested the following summer, is a common crop, accounting at the time for 75% of world wheat production. Isaac initially tried to develop relationships between climate factors and wheat yields using a conventional statistical technique - multiple regression analysis. He found that this type of analysis showed no meaningful relationship between climate and crop development, a result that, based on practical experience, was clearly wrong.

To determine a useable relationship, it was necessary to use a “deterministic” model, one that would actually simulated the growth of the wheat on a day-to-day basis. He used the CERES crop development model, developed for the U.S. Dept. of Agriculture, and used by the United States in its world crop-yield monitoring program (AGRISTARS). The model used daily solar radiation, maximum and minimum temperature and precipitation data.

As in the Ontario snow cover and natural-gas consumption studies mentioned above, Isaac used the outputs of the GISS and GFDL models to represent a climate changed by increased greenhouse gases. The data needed by CERES was not available from these models, which provided only monthly averages of temperature and precipitation, on coarse (500-km spacing) grids. It was therefore necessary to interpolate this data to a finer grid, and to produce simulated time series of the required daily temperature and precipitation values. Solar radiation was estimated from sunshine data.

The result indicate generally decreased crop yields, with reductions mostly in the 2 to 20% range, depending on location and climate change model used. Isaac points out, however, that these result assume no change in farming practices, for example in planting dates, strain of winter wheat grown, fertilization, pest management and irrigation. If crop yields started to suffer from changing climate, it is likely that farmers would change their practices, in ways that are difficult to predict.

The study may be a good one, however it is difficult to assess for two reasons. Isaac did not say how accurately the CERES model simulated observed wheat yields in Ontario, nor did he explain how he translated the GISS and GFDL monthly averages into the daily time series needed for input to CERES.

24. Snow Loads (Newark, 1984, 1990)

The National Research Council’s National Building Code provides standards to ensure the safe construction of buildings and other structures. A climatological supplement to the Code had been included for at least 60 years. It includes information on extreme high and low temperatures, extreme rainfall, annual precipitation, wind pressures (calculated from wind speed and temperature), and snow loads. Snow loads estimate the maximum weight of snow on roofs. Failure to properly account for these weights has led to a number of building collapses in various parts of Canada. While underestimates of the loads can be dangerous, overestimation can result in excessive construction costs. For example, it was possible to lower values for the 1990 Code, saving the building industry an estimated $46 million. Snow loads depend both on the amount of snow and rain, and the density of the accumulated snow.

Snow loads were first incorporated into the building code in 1941. They were modified several times thereafter - by Morley Thomas in the 1950's, by Don Boyd around 1960, and again by Boyd in the 1970's. Mike Newark, who took over as head of AID's building unit in early 1983, revised the values again, completing calculations for the 1985 Building Code. Further revisions were made for the 1990 edition. Values for about 1600 sites were calculated, of which about 680 were included in the Code. Extensive snow-density data was analysed, resulting in significant changes to a number of snow load figures, especially in B.C. and Yukon. Also the conversion of monthly snow depths from climatological stations to daily values was revised.

Not all of the locations in the Code correspond to sites with weather data. Values for sites with no observations were derived from maps prepared by smoothing and adjusting observed data, e.g. adjusting for elevation of the site. Maps and instructions were made available so clients could calculate values not included in the Supplement.

25. *Inversion (Maxwell, 1988-90)*

To my recollection, this was the only newsletter produced by AID, at least in the 1980's. First issued in the fall of 1988, it continued until 1990. Under the leadership of Barrie Maxwell, it provided a clearing house for information on climate activities relating to the North. Well prepared, it included a variety of articles on applied climatology, and provided information on relevant conferences, workshops and other activities. It promoted the collection and sharing of climate data from the region, a matter of importance in a data-sparse area.

Inversion did a good job of promoting the use of MSC's climate expertise and data, and more generally, arctic climatology. It was to be followed by "Aspire: news of the Canadian Climate Centre", which was produced for a brief period starting in 1992, before the demise of the CCC.

26. *Recent Temperature Trends in Canada (Berry, 1991)*

This project gave an overview of how temperatures had actually changed in Canada in recent decades, and compared these changes to those predicted by the Canadian Climate Centre General Circulation Model for an atmosphere with increased greenhouse gases. The intent was to see if already observed trends were similar to predicted ones. An analysis of data from 1950 to 1989 (using differences in decadal averages of temperature) showed that Canada had warmed west of a line extending from Lake Huron to the central Arctic Islands. To the east temperatures had decreased slightly. Maximum warming extended along a line extending from southern Saskatchewan to central Yukon. The latest result from the CCC GCM showed a similar maximum in southern Saskatchewan, but the maximum line ran straight north through the Arctic Islands.

The comparison indicated that the patterns of historic temperature changes in Canada did roughly correspond to the changes the GCM was predicting for approximately the middle of the 21st century, although the amount of warming indicated by the GCM outputs was much larger, presumably since it simulated much larger increases in greenhouse gases.

It is debatable whether this work, in itself, was climate applications. It was done in support of other application work relating to climate change.

27. *Irrigation Scheduling in a Seed Orchard Environment (Street, MacIver, 1986-92)*

In the 1980's there was considerable concern about the sustainability of Canadian forests, given ongoing rates of harvesting. Effective reforestation programs were therefore important. The Ontario Ministry of Natural Resources operated a number of "seed orchards" to produce genetically superior seeds for reforestation. Making available the correct amount of moisture to the seedlings in these tree farms was important to productivity. When they reached the seed producing stage, it was important to have some moisture stress. Later in the growth process more water was needed.

OMNR requested help in scheduling seedling irrigation, using a site near Sioux Lookout in northwestern Ontario as a test case. The site contained 16,000 black spruce seedlings, in an area of 5.2 hectares. Roger Street initiated this project, which was subsequently led by Don MacIver. The change in soil moisture was estimated each day using a water balance model that simulated precipitation, evaporation, and movement of surface and subsurface water. Measurements of temperature, relative humidity, total precipitation, and solar radiation were used. Calculated soil moisture values were compared to measurements on a weekly basis.

This experiment proved successful – the information provided was of sufficient value to orchard operations that OMNR provided funding to AID for setting up programs at several other seedling nurseries. By 1992 a computer model (The Soil Moisture and Irrigation Model, SIAMM) had been completed. It provided an automated system for determining when irrigation was needed. The user entered daily values of the weather parameters plus the previous day's irrigation amount, from which the system would calculate today's needed duration of irrigation. Weather data could be input directly from data loggers. This automation of the process allowed transfer of the technology to OMNR.

Was this work climate applications? The development of the system certainly was, since it was based on climate-tree development relationships. Had the system been operated indefinitely by AID, rather than transferred to OMNR, the project would clearly have moved outside the realm of climate applications.. However, operational testing of a system is a legitimate part of the applications specialist's work.

The project was well planned and executed, and provided another good example of how the proper use of climate information can increase efficiency in a particular economic sector.

28. Estimating Icing Amounts Caused by Freezing Precipitation in Canada (Yip, 1995)

This project is an example of climate applications at its best, in the sense that it addresses an important climate-related problem, and by working with client agencies, develops practical standards needed for design purposes. During freezing rain storms, the accumulation of ice on power lines, communication towers and other structures can lead to damage including collapse, if the design of a structure does not properly take this accumulation into account. The damage caused by the January 1998 ice storm in eastern Canada, in which hundreds of thousands of people were left without power for extended periods, was an extreme case.

Study of this phenomenon by MSC staff dates back at least the 1950's, and includes work by Don Boyd, Pierre Chaine, Gordon McKay, Morley Thomas, Harland Thompson and other MSC staff. The subject was also of concern to the National Research Council, which collected a variety of ice accumulation data.
In cooperation with electric utility companies, and with funds provided by the Department of Energy Mines and Resources (of which NRC is a part), AID started work in 1983 to develop an advanced ice accumulation model, with a substantial part of the work being done under contract. Les Welsh provided leadership to the project in the mid-1980's. He was active in the 3rd International Workshop on Atmospheric Icing of Structures held in 1986, co-editing the conference proceedings.

Tsoi Yip took over the project in 1989 when she joined AID. This paper, prepared by Tsoi, presents the results of the work. Tsoi and her colleagues assessed nine ice accretion models. The Chaine-Skeates model was selected as the best. It was found that the rate of ice accumulation was quite sensitive to the diameter of the structural element exposed (smaller accumulates faster), the rate of precipitation, and wind speed (hence elevation above the ground).

Extreme values of ice accumulation (30-year return periods) were calculated using the model, and compared to the equivalent values derived from 16 years of observed data from Hydro Quebec. Accuracy of the model was judged to be good. The highest amounts were projected for the eastern coasts of Newfoundland and Nova Scotia, with amounts being relatively high in most areas from the lower Great Lakes-St. Lawrence River south-eastward. Results were also presented that permit the estimation of the variation in ice accumulation with height.

29. Mackenzie Basin Impacts Study (Cohen et al., 1990-97)

This project, developed under the leadership of Stewart Cohen, began in AID, and by the mid-1990's moved to ACSD, in the Adaptation and Impact Research Branch. (See Section 6.1 regarding organizational changes.)   The MBIS was much larger in scope than other climate-change related projects originating in AID.   It included about 23 studies on the effects of change, divided into seven categories – water, land, vegetation, wildlife, people, and integrated assessment models.

For the most part, these studies did not give a definitive answer to the question "What will be the effects of climate change?" The uncertainty regarding the climate change data precluded this. In additional, in many cases the relationships between climate and other components of the environment were complex and poorly understood, or sufficient data was not available. However, it was never the intend of this study to provide definitive answers. It was aimed at providing examples of what might happen, and alert people to the fact that it may be necessary for them to cope with a changing environment.

A valuable part of the MBIS final report was the results of a workshop held in 1996 Six "roundtables" brought together individuals with a wide range of backgrounds to discuss study results. They concluded that, while the MBIS studies did not provide definite answers, they were valuable in that they did focus attention on the fact that major changes were likely in the North and elsewhere. This should result in decision makers being aware that long-tem plans may be affected by changes in such things as the permafrost regime and in wildlife numbers and ranges. There was also a consensus that future monitoring of changes was important, with the understanding that observed changes may not be temporary variations, but part of long-term trends. Successful adjustment to the changes by northerners was considered likely, provided they did not come about too quickly.

Given the ambiguity of the work and the diversity of interests involved, the MBIS was a challenging undertaking. Stewart Cohen, and other participants, did a good job of seeing it through to a successfully conclusion. As suggested by some of the participants, this initiative would likely have benefited by complementing the rather scholarly MBIS final report with a summary written to more effectively to catch the attention of the general public.

30. Climate in the Mackenzie Basin and Northern-Nesting Geese (Maarouf, Boyd, 1997)

Most if not all of the work on this study was done after the elimination of AID. It is included here because it was the only scientific study in the MBIS (see preceding item) whose principal author was a AID member.

The work was carried out by Abdel Maarouf, who had worked on climate influences on humans and animals in AID, and Hugh Boyd of the Canadian Wildlife Service. Ideally the study would have related climate variables to the breeding success of geese in the

Mackenzie Basin. Unfortunately no such goose data was available. The studied is primarily based on the number of young geese shot by hunters further south in Canada, and in the U.S.A. There were several problems with this data, e.g. it was not know with certainty how many of the birds caught originated from areas other than the Mackenzie Basin.

The authors had difficulty relating the goose data to climate variables. They classify average percentage of young geese as either High, Medium or Low, then use a statistical technique to determine which monthly averages of climate variables best determine these categories. Of the 23 years of data at their disposal, 16 fell into the normal category, limiting the success of their analysis. They did find possible connections – for example warmer spring temperatures seem to have a positive effect on breeding. However the links were tenuous, and the authors were understandably reticent to extrapolate their findings to climate change scenarios. Instead they conclude, or perhaps more accurately give an educated guess, that primarily indirect effects of climate change - for example changes in the tree line, in the permafrost regime, and in fire frequency - will have a greater effect, and will lead to a decrease in goose population.

Appendix B - Notes

These notes are to references that appear in the main text.

1. Tabulating machines and computers

In the 1950-55 period tabulating machines were introduced into MSC climatology, and most of the archive was converted to punched (Hollerith) card format. These machines could read and sort punched cards, and could be programmed to perform simple tasks, by means of moving wires about in a manner similar to the operation of an early telephone switchboard. This allowed selection of climate records by predetermined elements, counts of records selected, and the addition of values of a given parameter, e.g. to calculate averages.

In early 1965, the first computer, an IBM 1440, was rented for a year, for $322,000 (adjusted for inflation to year 2000 dollars). Shortly thereafter, an IBM 360/30 was purchased for $1,600,000. The tabulating machines the computers replaced had been rented for about the same cost as the 1440. In addition to providing more sophisticated data analysis, the computers could be programmed much more easily, using punched cards or terminals. As a result, climate applications specialists could write their own analysis programs, and modify them to get the specific results clients required.

Bev Cudbird was put in charge of machine processing in 1950, and continued to run the tabulating machine/computer operation until his retirement in the mid-1970's.

The use of personal computers by other than hobbyists started to grow in the late 1970's. I'm not certain when they first came into use in AID, however it was 1986 before they were used widely in the Division. These devices streamlined data processing, especially of smaller data sets that could be transferred from a large computer. They also permitted the use of a broader range of analysis software, much of which could be purchased "off the shelf", and permitted faster, better quality output, e.g. of maps and graphs.

2. Number of Climate Studies

Information on the annual number of climate studies is based on studies listed in four editions of the *Bibliography of Canadian Climate.* These cover the period 1763-1957, 1958-1971, 1972-1976 and 1977-1981. The first two were prepared by Morley Thomas, the third by Morley and Dave Phillips, the fourth by Dave. The publications listed include those dealing with all aspects of Canadian climate, so are not restricted to climate applications. It is possible that changes in the criteria for selection of publications affect this time series. In particular, the criteria for inclusion may have become more liberal after 1971 (Thomas, 2001a).

3. Not used.

4. AID resource figures

In Figure 2, 1989/90 values are derived from Divisional work plans, hence are for April 1989 to March 1990. Values for 1973 and 1980 were estimated on the basis of descriptions of individual projects underway, and hence are less accurate. However, the 1989-90 figures can't be considered completely accurate - work plans did undergo some changes as the year progressed.

5. Cost recovery

In the 1970's and 1980's MSC differentiated between "basic" and "special" services. The former applied to services benefiting a wide variety of Canadians, and were provided either free or at a nominal charge. Special services were aimed at the needs of specific individuals or organization. The costs of special services were billed to the client.

This policy left considerable room for interpretation. In practice, AID did not charge for preparation of publications like the *Climate of the Arctic Islands*, that were intended as a reference for a broad range of individuals and organizations. (Most customers did have to pay for these publications, but the proceeds from the sales went elsewhere in the government, to cover printing and distribution costs.) Work in support of other components of Environment Canada, or which related closely to Department objectives, was also done free of charge. Examples were support to the Department's regional offices, and the majority of climate-change work. Work involving the promotion of the use of climate to a variety of clients was also done free of charge. *Forest Climate '86* *wa*s an example. Representing MSC at local, national and international meetings was usually considered a free service, provided the function fitted Department objectives, which was usually the case.

The part of AID's program relating to petroleum exploration and development, and solar and wind energy, was partly charged to clients (either the private sector or other federal agencies) and partly supported out of AID's main budget. The rational was that the work supported both Environment Canada aims, and those of other organizations. Other work for government agencies or the private sector was usually paid for by the client.

The policy governing charging clients was important to AID because about 85% of it's regular budget was salaries, leaving only modest amounts of money for travel, professional development, contract work, etc.

6. Seconded meteorologists – a breakthrough for climate applications

Until the secondment of meteorologists to a variety of government organizations beginning in 1951, there had been climate applications work done by MSC, but it had been limited. Thomas (1972) comments as follows. He is referring to building climatology, but his remarks could also be applied to seconded meteorologists working in other areas. “Meteorological Service participation in this work was somewhat of a breakthrough, since in earlier years the rules had been to provide data only as observed – when no data were available the enquirer was told ‘sorry but we don’t have this information’. In the preparing of design values, especially wind loads and snow loads, systems had to be devised by which values that had been empirically estimated were given to users and in a sense this can be considered a breakthrough and the real start in applying meteorology for the health, safety and economic advantage of Canadians.”

The following is a list of seconded climatologists, from Thomas (2001a) and Robertson (1998). “Agriculture” and “Forestry” refer to what are currently (2001) called Agriculture and Agri-Food Canada, and the Canadian Forest Service. “Building Research” refers to the National Research Council’s Division of Building Research (currently called the Institute for Research in Construction). “PFRA” refers to a branch of Agriculture Canada – the Prairie Farm Rehabilitation Administration, based in Regina.

MSC Seconded Climatologists				
		Started with MSC	**Seconded**	**Destination when left**
Agriculture	**Ottawa**			
George	Robertson	1938	1951	Dept. of Agriculture
Dan	Williams	1955	1960	Dept. of Agriculture
Stu	Edey	1955	1960	Dept. of Agriculture
Forestry	**Ottawa**			
Hugh	Cameron	1938	1951	MSC, FSD, 1953
Les	MacHattie	1940	1954	Dept. of Forestry
Mike	Webb	1961	1964	MSC
Building	**Research**			
Morley	Thomas	1941	1951	MSC, Climatology, 1953
Don	Boyd	1943	1953	Retired, c. 1980
PFRA	**Regina**			
Gord	McKay	1943	1959	MSC, Climatology, 1966
Ontario				
Jim	Bruce	1948	1955	MSC, Hydrometerology
Don	McMullen	1940	1958	Govt. of Ontario
Also, J.A. Turner was seconded to B.C. Forestry, and Wilbur Sly to				
Agriculture, Ottawa and Beaverlodge				

7. Supplemental funding data – Figure 6

The “structural icing” included in Figure 6 was for study of ice accumulation on electrical transmission lines, and towers. Whether this should be included as part of the “energy program” is debatable. Also, the figure does not include money earned from charging customers for certain other services, e.g. building design values and support to the Ontario Ministry of Natural Resources for tree-farm operations. Combined revenue from these sources was less than $100,000 per year.

Appendix C – Where Did AID Staff Go?

Information about people’s current positions was obtained from the MSC Internet site in mid-2001, or from personal enquires made at various times in that year. “ACSD” means the Atmospheric and Climate Science Directorate of MSC, “AMWS” means the Atmospheric Monitoring and Water Survey Directorate, PCA the Policy and Corporate Affairs Directorate.

Retired

Mal Berry, Ed Birch, Ron Crowe, Jack Emmett, Bruce Findlay, Angus Headley, Marilyn Lemaire, Barrie Maxwell, Dave McNichol, Eli Mukammal, Mike Newark, Phil Sajecki, Isaac Savdie, Rudi Treidl, Dan Williams, Denis Walsh

Adaptation and Impacts Research Branch

Stewart Cohen (University of British Columbia),
Dave Etkin (University of Toronto),
Abdel Maarouf (University of Toronto),
Roger Street (AIRB Director, MSC Headquarters),
Walter Skinner (part time, MSC Headquarters).

MSC Headquarters – Other jobs relating to climate

Bob Morris (Manager, Climate and Water Products Division, AMWS),
Tsoi Yip (Manager, Climate and Water Archives Division, AMWS),
Walter Dnes (Climate and Water Products Division, AMWS),
Malcolm Geast (Climate and Water Information Branch, AMWS),
Don MacIver (Senior Science Advisor, Science Assessment & Integration Branch, ACSD),
Joan Masterton (Director, Science Assessment & Integration Branch, ACSD),
Lucie Vincent (Climate Monitoring and Data Interpretation Division, ACSD),
Walter Skinner (part time, Climate Monitoring and Data Interpretation Division, ACSD),
Tom Agnew (Climate Processes and Earth Observation Division, ACSD)

MSC Headquarters – other jobs

Don McKay (ex-Director, Air Quality Research, ACSD, currently on assignment),
Rick Berry (Manager, Business Planning and Development Branch, PCA),
Bob Paterson (Forecast Research Division, ACSD)

MSC Regions

Billie Taylor (Beattie), (Air Quality Meteorologist, Atmospheric Science Division, Atlantic Region*),*
Heather Auld (Manager, Atmospheric Science Division, Ontario Region)

Other

Les Welsh, (Oil, Gas & Energy Division, Environment Canada),
John Deary (Camp Borden, ACSD)

Unknown

Bob Beal, Ralph Harvey, Janet Isaac, André Lachapelle, Neil Sargent

Appendix D – Organization 1954 to 1973, Staff 1971 to 1979

1. Components of AID 1954-72

The following table shows the MSC Headquarters organization of climate applications. In the 1966-72 period numerous changes were made to AID's organization. The table oversimplifies these, and may contain errors. Industrial Climatology and Physical Climatology were initially (1966-67) combined in Resources and Engineering. The organization in 1972 was to remain largely unchanged until the early 1990's except for the merging of Physical and Agricultural Climatology in the late 1980's. A hydrometeorology unit existed from the late 1950's to the early 1990's, but it was removed from Climate Applications in about 1960.

In the table, Climatology Division is an earlier name of the Climate Applications Branch. Climate Research and Special Programs, and Applications and Consultation, are predecessors of AID.

MSC Headquarters Climate Applications Components									
Year:	54	59	63	66	67	68	69	71	72
Special Investigations and Research	X								

Arctic Climatology/Meteorology		X	X	X	X	X	X	X	X
Bioclimatology/Microclimatology		X	X	X	X	X	X	X	
Climate Analysis			X	X					
Resources and Engineering				X	X				
Industrial Climatology/Meteorology						X	X	X	X
Topoclimatology/Physical Climatology						X	X	X	X
Agricultural Climatology/Meteorology								X	X
Hydrometeorology		X							
Components Reported To:									
Chief, Climatology Division (Boughner)	X	X	X						
Supt., Climate Research and Special Programs Section (McKay)				X	X	X	X	X	
Chief, Applications and Consultation Division (McKay)									X

2. AID staff 1971 to 1979

The following table lists AID professional staff in the 1970's. This list differs from the AID 1980's staff list (Figure 4) in that it includes temporary employees. Permanent professional staff through the decade numbered about 11. In comparison, in the 1980's it averaged about 14. The number of temporary employees peaked at about 5 in 1973.

Information on technical and other staff is limited. Jim Young provided administrative and technical support to the Division until about 1974, followed by Jim Woods until 1976. Technical support was provided for various periods by John Metcalfe (Agriculture); Dan Roherty, Peter Skeates, and Julie Turner (Industrial); Angus Headley, Fred Richardson and Jack Emmett (Arctic); Alf Waymann (Topoclimate); and Denis Walsh (Biomet.). Olga Poulton provided clerical support, while Hilda Milne followed by Sheila Annis were Division secretaries.

AID Professional Staff, 1970's							
Year:	71	73	75	77	78	79	
Month:	9	11	12	1	3	3	
Name							Worked in/as
Gordon McKay	&	&	&				Division Chief
Howard Ferguson				&			Division Chief
Ed Birch		X	X	X	X	X	Agriculture
Henry Stanski			X				Agriculture
Rudi Treidl	&	&	&	&	&	&	Agriculture
Andre Lachappelle					X	X	Arctic
Barrie Maxwell	X		X	X	X	X	Arctic
Bev Burns	X	X					Arctic
Harland Thompson	X	X					Arctic
Mal Berry		X	&	&	&	&	Arctic
Roy Woodrow	X	X	X				Arctic
Isaac Savdie		X	X				Arctic, Agriculture
Eli Mukammal	&					&	Biometeorology
Don Boyd	X	X	X	X	X	X	Industrial (NRC, OW)
Bob Verge	&	&	&	&			Industrial
Don McKay					X	X	Industrial
Pierre Chaine	X	X					Industrial
Thorne Won			X	X	&	&	Industrial
Phil Aber		X					Management Training
Billie Webber (Beattie)		X					Physical
Bruce Findlay	X	X	&	&	&		Physical
Dan Bondy		X	X				Physical
Glen Bristow		X					Physical
Joan Masterton		X	X	X	X	X	Physical
Leslie Taylor (Malone)			X				Physical
Richard Leduc						X	Physical
Ron Crowe		X	X	X	X	X	Physical
Key							
& - Section or Div. Manager							

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