McGILL UNIVERSITY
Department of Geography

CLIMATOLOGICAL BULLETIN

NO. 20
OCTOBER 1976

McGILL UNIVERSITY, MONTREAL

ISSN 0541-6256

The CLIMATOLOGICAL BULLETIN is published twice a year in April and October. The subscription price is Five Dollars a year. Please address orders and inquiries to:

Department of Geography (Climatology)
McGill University
P.O. Box 6070, Station A
Montreal, Quebec, Canada
H3C 3G1

CLIMATOLOGICAL BULLETIN

CONTENTS

No. 20 October 1976

The Spatial Variability of Daily Values of Solar Radiation for British Columbia and Alberta, Canada,
by P.W. Suckling and J.E. Hay..........page 1

The Influence of a Snowpack on the Amount of Solar Radiation Received by a Vertical, South-facing Wall,
by R.J. Hague and G.L. Werren...........page 8

A Climatologist in the Soviet Union
by Marie Sanderson......................page 17

Recent Doctoral Theses in Climatology.............................page 25

News and Comments..page 27

THE SPATIAL VARIABILITY OF DAILY VALUES OF SOLAR RADIATION FOR BRITISH COLUMBIA AND ALBERTA, CANADA

by

P.W. Suckling and J.E. Hay*

Introduction

Knowledge of the spatial distribution of solar radiation is becoming increasingly important due to the emerging interest in solar energy utilization as reviewed by Chant and Ruth (1975) and Swartman (1975). The number of observing stations in Canada is limited (Figure 1). To supplement this data base numerical models may be used (e.g. Hay, 1970; Davies et al, 1975) or data spatially interpolated from the existing observational network. Wilson and Petzold (1972) investigated the spatial variability of measured solar radiation for selected stations in southern Canada for the summers from 1967 to 1971. They found that the standard deviation of the daily differences of measured solar radiation between station pairs was closely related to the distance between those stations. The present study represents a similar analysis but for stations located in British Columbia and Alberta.

Procedure

Daily totals of solar radiation were analysed for the five-year period 1968 to 1972 for the stations listed in Table One. A total of 28 station pairs were available for analysis. For each pairing, measured solar radiation was correlated and the standard deviation of solar radiation differences (following the analysis of Wilson and Petzold, 1972) was calculated. These were then compared to the distance

* P.W. Suckling is a graduate student and J.E. Hay is an Associate Professor, both at the Department of Geography, University of British Columbia, Vancouver, B.C.

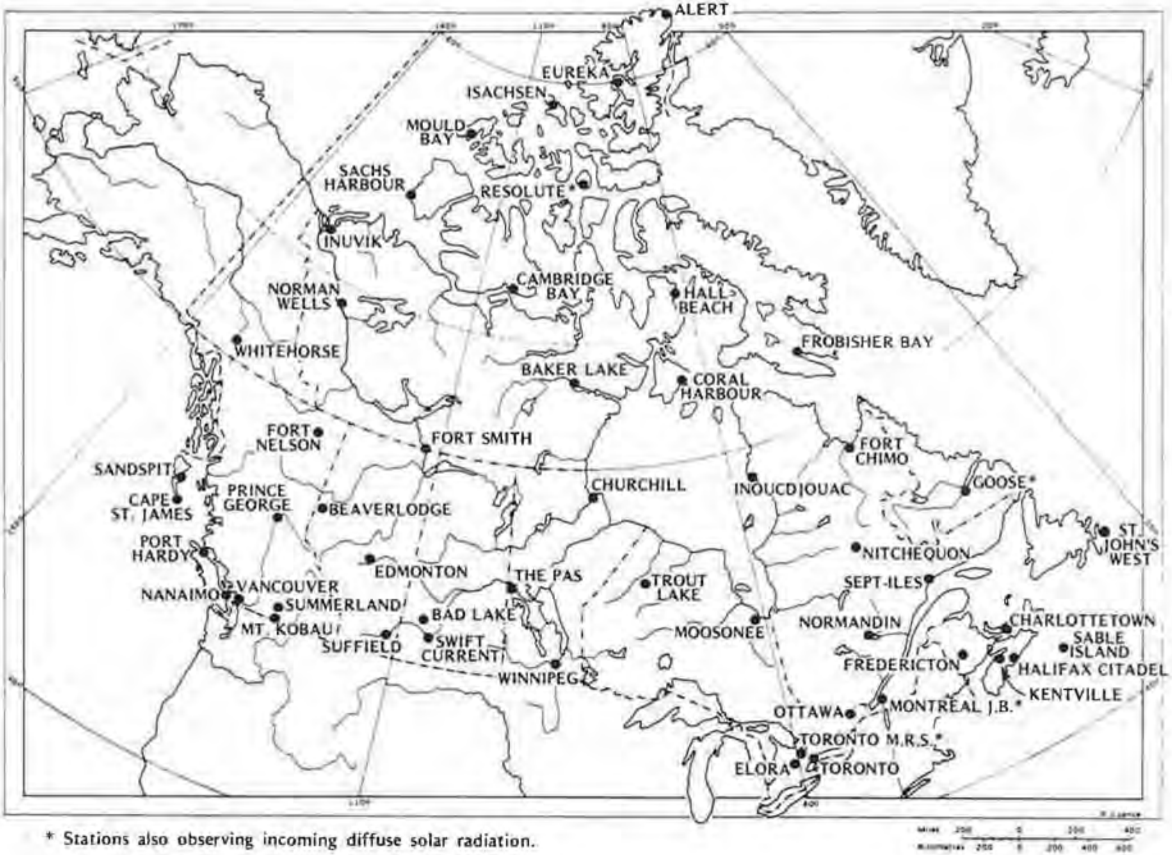

Fig. 1. Location of solar radiation observing stations in the Canadian Atmospheric Environment Service Network, as of January, 1975.

between station pairings (Table Two).

Results

Figure 2 indicates that there is a strong relationship between the correlation of measured solar radiation for station pairings and distance between stations. A best-fit line has been drawn by eye. Following the work of Wilson and Petzold (1972), Figure 3 shows the relationship between the standard deviation of solar radiation differences and distance between stations. Again, a strong relationship exists. The range of distances covered in the earlier study was 14 to 238 km, whereas the present study extends the analysis to a range of 55 to 1180 km. The relationship of Wilson and Petzold is also shown in Figure 3 and indicates somewhat higher values of the standard deviation for a given distance. This could be due to:

1. the fact that their study was for summer only when solar radiation values are higher and hence standard deviations could be expected to be higher relative to those for an entire year;

2. the scale of weather systems influencing the spatial variability of the solar radiation being larger in western Canada than in their study area.

Figure 2 shows that, even for distances over 1000 km, solar radiation between stations is still correlated as high as 0.7. However, from Figure 3, this represents an error (of one standard deviation) of about ±5 MJ m^{-2} day^{-1}. Even for a separation of only 250 km errors of at least ±3.5 MJ m^{-2} day^{-1} can be expected. These errors may be significant for solar energy applications.

For example, for a solar collector area of 70 m^2 an error of ±3.5 MJ m^{-2} day^{-1} means that the average amount of energy incident on the collector could only be specified to within ±245 MJ day^{-1}. However, if a solar system conversion efficiency of 20% is assumed, this variability reduces to ±50 MJ day^{-1}. In reality the possible error would likely be greater than this value since there is the need to convert the horizontal data used here to that relevant to the orientation of the collector, a conversion which in itself is not without error (Garnier and Ohmura, 1970). By way of comparison, consider a house with a heated area of 135 m^2 and a heat loss characteristic of 102 KJ m^{-2} (Degree F Day)$^{-1}$ (HUDAC, 1975) located in Vancouver where the mean annual degree (F) day value is 5644 (Atmospheric Environment Service,

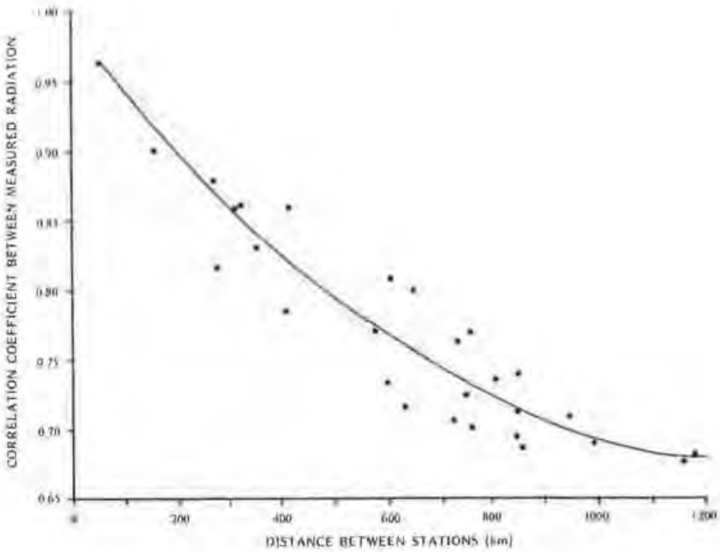

Fig. 2. Variation of correlation coefficient for solar radiation between stations with distance between station pairings.

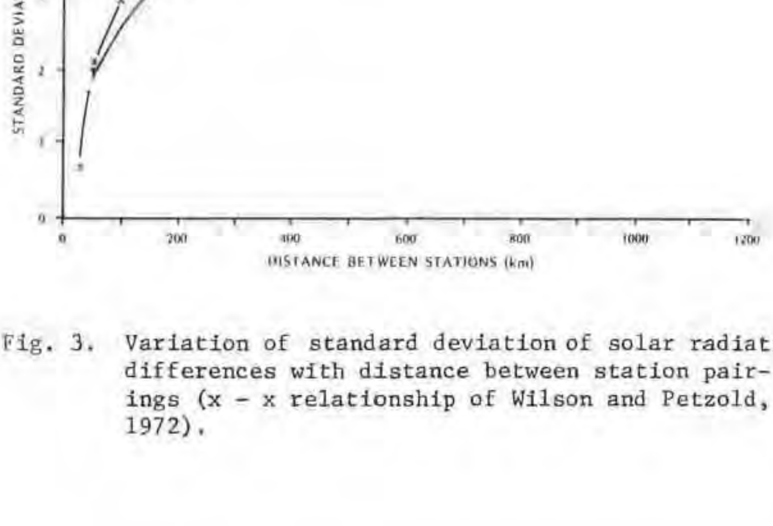

Fig. 3. Variation of standard deviation of solar radiation differences with distance between station pairings (x - x relationship of Wilson and Petzold, 1972).

TABLE ONE

Solar Radiation Stations Used in the Analysis

Station	Latitude (N)	Longitude (W)
Sandspit, B.C.	53°15'	131°49'
Cape St. James, B.C.	51°56'	131°01'
Port Hardy, B.C.	50°41'	127°22'
Nanaimo (Departure Bay), B.C.	49°13'	123°57'
Vancouver, B.C.	49°15'	123°15'
Summerland, B.C.	49°34'	119°39'
Beaverlodge, Alta.	55°11'	119°22'
Edmonton (Stony Plain), Alta.	53°33'	114°06'

TABLE TWO

Distances (Km) Between Stations

	Sandspit	Cape St. James	Port Hardy	Nanaimo	Vancouver	Summerland	Beaverlodge	Edmonton
Sandspit	-	155	410	720	750	940	830	1180
Cape St. James		-	280	590	625	840	850	1160
Port Hardy			-	305	350	575	740	980
Nanaimo				-	55	315	750	850
Vancouver					-	265	725	800
Summerland						-	640	600
Beaverlodge							-	410
Edmonton								-

1971). The mean daily space heating requirement for such a house is 213 MJ. Therefore the variability of ±50 MJ day^{-1} represents approximately 25% of the average daily domestic space heating requirements.

Conclusions

Strong relationships between the correlation coefficient for measured solar radiation and the standard deviation of solar radiation differences versus distance between stations have been shown to exist for British Columbia and Alberta locations. These substantiate the conclusions reached by Wilson and Petzold (1972) in their study for selected stations in southern Canada. The nature of the relationship is such that for small (i.e. less than 400 km) station separations the average differences in daily radiation totals show a strong dependency on distance while for separations over about 600 km the differences stay relatively constant but high. Average errors of up to ±5 MJ m^{-2} day^{-1} and at least ±3.5 MJ m^{-2} day^{-1} can be expected when observed solar radiation data are extrapolated for distances of 600 and 250 km respectively. These errors may be significant especially for solar energy applications. Therefore, a more dense network of solar radiation data is needed. As noted by Hay (1975), dense measuring networks using pyranometers are not economically viable. Therefore, the required values of solar radiation must be estimated using standard synoptic weather data as inputs to numerical models rather than interpolated from the sparse observational network.

ACKNOWLEDGEMENTS

This study was supported, in part, by Atmospheric Environment Service and National Research Council funds.

REFERENCES

Atmospheric Environment Service, 1971: Supplemental Heating Degree-Day Normals below 65°F - Based on the Period 1941-70, Climatic Data Series #2-71, Toronto, 2 pp.

Chant, R.E. and D.W. Ruth, 1975: "Solar Heating in Canada", The Potential of Solar Energy for Canada, Conference of the Solar Energy Society of Canada Inc., Swartman, R.K. (ed.), Ottawa, Part III, pp. 1-10.

Davies, J.A., W. Schertzer and M. Nunez, 1975: "Estimating Global Solar Radiation", Bound. Layer Meteor., Vol. 9, pp. 33-52.

Garnier, B.J. and A. Ohmura, 1970: "The Evaluation of Surface Variations in Solar Radiation Income", Solar Energy, Vol. 13, pp. 21-34.

Hay, J.E., 1970: Aspects of the Heat and Moisture Balance of Canada, Ph.D. Thesis, University of London, 2 vols., 322 pp.

Hay, J.E., 1975: "Solar Energy Utilization in Canada: a Climatological Perspective", The Potential of Solar Energy for Canada, Conference of the Solar Energy Society of Canada Inc., Swartman, R.K. (ed.), Ottawa, Part I, pp. 23-40.

Housing and Urban Development Association of Canada (HUDAC), 1975: A Builder's Guide to Energy Conservation, Toronto, 20 pp.

Swartman, R.K., 1975: "Solar Cooling", The Potential of Solar Energy for Canada, Conference of the Solar Energy Society of Canada Inc., Swartman, R.K. (ed.), Ottawa, Part III, pp. 11-17.

Wilson, R.G., and D.E. Petzold, 1972: "Daily Solar Radiation Differences between Stations in Southern Canada: a Preliminary Analysis", Climatological Bulletin, Department of Geography, McGill University, Montreal, No. 11, pp. 15-22.

THE INFLUENCE OF A SNOWPACK ON THE AMOUNT OF SOLAR RADIATION RECEIVED BY A VERTICAL, SOUTH-FACING WALL

by

R.J. Hague and G.L. Werren*

In considering the incidence of solar radiation on a sloping surface it is often desirable to examine the contribution made by reflection from neighboring surfaces in addition to the more commonly considered sources of direct and sky-diffuse radiation. This is particularly needed in snow-covered regions since the high albedo of snow makes it potentially an important contributor to the flux of total short-wave radiation on a given surface.

It was the objective of the present small-scale study to carry out an experiment which sought to establish an estimate of the quantity of irradiation on a south-facing wall which could be attributed to the "specular" reflection, or forward scattering, of a snowpack.

Such a study seems justified due to:

(a) the apparent paucity of information as to the nature of the specular contribution of a snowpack to radiation receipt on a neighboring sloping surface;

(b) an indication in some recent work (Dirmhirn and Eaton, 1975) that spring snow-covers appear to contribute a substantial specular component to their reflection of solar radiation; and

(c) the recent development of interest in the investigation of the potential for solar energy utilization in Canada and its use in housing development in northern territories and elsewhere.

The assumption that a snow-covered surface is an almost perfect diffuser of incident solar radiation seems to be invalid. It

* The authors of this report are both graduate students in the Department of Geography, McGill University, Montreal

appears, at least theoretically, that at relatively low solar angles and over a fresh, well-structured snow surface, a good proportion of radiation will be reflected forward. This then, may be assumed to increment considerably the short-wave radiation received on a surface which is directed toward the sun. This assumption is tested empirically in the present study.

The site chosen for the experiment was a large field belonging to the Brace Institute situated in the Macdonald College Campus of the McGill University complex, at Ste-Anne de Bellevue, Quebec. This location was suitable for the experiment since it was free from vertical obstructions to solar exposure and from pedestrian or vehicular traffic which would disturb the snow surface. Also there was a small hut on the walls of which to mount some of the necessary instruments. The site did possess several small windvanes to the southwest but at no time did these structures influence the instruments used for data collection. Figure 1 depicts the instrumentation layout of the Macdonald College site.

Meteorological Conditions for the Day of the Study

The day of observation, February 23, 1976, was almost ideal for the experiment. Brilliantly clear skies were experienced, with the exception of a small and distant cloud due to some local evaporation over the surface of Lac St. Louis which presented no obstruction to the direct radiation. The ambient temperature (measured every 15 minutes) ranged from -22°C to -13°C.

Instrumentation

Figure 1 presents information concerning the instrumentation of the experiment. The instruments included a Lintronic Dome and a Kipp and Zonen Solarimeter mounted on the south wall which monitored the incoming solar radiation incident on the vertical surface. On the north wall a similar pair of instruments were used to measure the diffuse radiation. The incoming radiation on a horizontal surface was measured by a "sol-a-meter" solarimeter located on the roof of the hut. The readings from this instrument were coupled with those obtained from a Swissteco Net pyradiometer, in order to calculate the albedo of the snowpack. The responses from all of the instruments were passed through

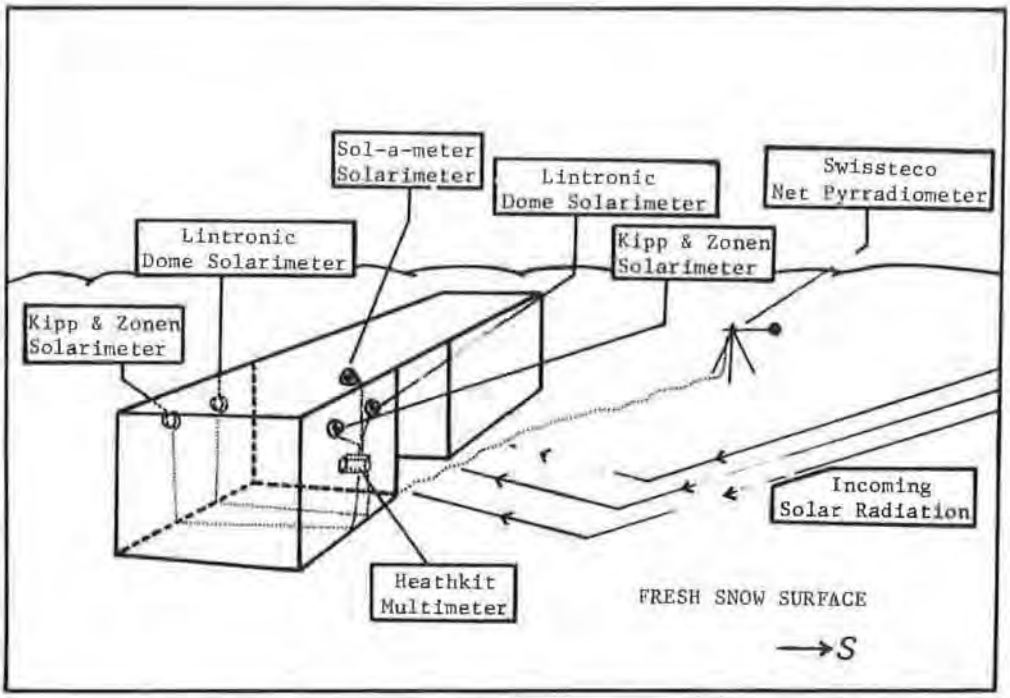

Fig. 1. Location of instruments at the study site.

TABLE ONE

View Factors of the Instruments

Instrument	Location	Height	View Factor
Kipp & Zonen	North wall	1.8 m	103.12 m
Lintronic	North wall	1.8 m	103.12 m
Kipp & Zonen	South wall	2.0 m	114.57 m
Lintronic	South wall	2.0 m	114.57 m
Silicon cell	Roof	Not applicable	sky
Swissteco	Field	1.3 m	490 m^2

a relay system to a Heathkit Multimeter located in the hut and maintained at a constant temperature.

Table One presents the viewfactors for each of the instruments used in the study. The calculation of these values involved a simple trigonometric solution involving a knowledge of the height of the instrument together with the lowest angle of incidence of radiation impinging on the instrument, in this case assumed to be one degree. Therefore multiplication of the instrument height by the cotangent of this angle will yield the desired result. In the case of the net radiometer a figure obtained from Latimer (1971) was used to calculate the area viewed. The large view factors of each of the instruments (Table One) rendered minimal the amount of snow surface disturbance suffered during the installation procedure. All instruments were used to calculate the snowpack radiative enhancement factor with the exception of the Kipp and Zonen solarimeter which was mounted on the south wall. This instrument yielded incongruous results when compared with those of the other instruments, probably due to uncertain instrument calibration. Furthermore, the instrument was attached to an integrating recorder rather than in instantaneous readout and thus the fact that the sampling interval was not exactly constant would cause difficulties when the readings from the instruments were compared.

Methodology

When the values obtained from the instruments were considered, it was necessary to divide the global radiation into its direct and diffuse components. The values recorded on a north wall during the experiment are representative of the diffuse radiation falling on this surface. However, since the day being observed was particularly clear, the standard cosine squared approximation of the diffuse radiation falling on a horizontal surface from a knowledge of the vertical surface cannot be utilized due to the uneven contribution of diffuse radiation from different parts of the sky hemisphere (Robinson, 1966; Ohmura, 1968). It was therefore necessary to devise an alternate method of estimating this parameter. The method which was used involved a scrutiny of radiation records for the locality to find a day with a similar daily total and distribution of radiation. The percentage of diffuse contribution to the radiation income was subsequently calculated from these

TABLE TWO

Global Radiation and Components
(langleys per hour)

Hour Ending	Global	Direct	Diffuse[1]	Diffuse[2]
0800	4.0	3.0	1.0	4.65
0900	17.1	13.7	3.4	13.77
1000	29.3	24.9	4.4	19.62
1100	38.4	32.7	5.7	23.79
1200	43.0	36.5	6.5	26.34
1300	43.5	37.0	6.5	28.32
1400	39.9	33.9	6.0	27.42
1500	31.9	27.1	4.8	25.38
1600	20.2	16.1	4.1	21.33
1700	8.0	6.0	2.0	11.01
Total:	275.3	230.9	44.4	201.63

1. Calculated as explained in text.
2. Calculated from north wall radiation by cosine squared approximation.

TABLE THREE

Instrument Calibrations

Instrument	Serial No.	Calibration	Date	Temp.	Comp.
Lintronic	s-543	25.96 mv/ly	1974	18.33°C	-.2%/°C
Solarimeter	513-105	27.16 mv/ly	1974	18.33°C	-.2%/°C
Swissteco	6697	S.W. 28.07 mv/ly	1969	26.67°C	none
Net Radiometer		L.W. 26.40 mv/ly	1969	26.67°C	none
Kipp & Zonen Solarimeter	1755	7.5 mv/ly	1969	20°C	-.2%/°C

Silicon Cell Solarimeter no. 1226 1961
High Range ly/min=(.17 x mv -.023)
Low Range ly/min=(.338 x mv -.049)
Temperature compensation not necessary.

TABLE FOUR

Hourly Totals of Measured Radiation

Hour Ending	--------Global Radiation (lys/hour)------- South Wall(L)*	North Wall(L)*	North Wall(K)*	Hori-zontal	Rn over Snow (ly/hr)	Albedo
0800	13.70	2.33	2.06	4.01	0.54	0.865
0900	41.06	6.89	6.93	17.13	1.71	0.900
1000	55.34	9.81	10.16	29.31	3.69	0.874
1100	64.20	11.90	12.83	38.43	5.55	0.856
1200	68.27	13.17	14.75	42.99	6.62	0.846
1300	68.37	14.16	15.65	43.50	6.78	0.844
1400	65.93	13.71	14.75	39.95	6.24	0.844
1500	56.67	12.69	13.04	31.85	4.85	0.848
1600	39.92	10.67	10.40	20.18	2.94	0.854
1700	18.09	5.51	5.30	8.01	0.65	0.919
1800	0.38	0.20	0.00	0.00	0.00	N.A.
Total:	491.93	101.04	105.87	275.36	39.57	$\bar{a}$ .865

* L = Lintronic; K = Kipp & Zonen

TABLE FIVE

Radiation Increment on South Wall

Hour Ending	----Global (ly/hr)--- Predicted	Observed	-----Increment------ ly/hour	%
0800	16.30	13.70	*-2.60	-15.96
0900	30.35	41.06	10.71	35.29
1000	43.67	55.34	11.67	26.72
1100	52.26	64.20	11.94	22.84
1200	56.05	68.27	12.22	21.80
1300	56.08	68.37	12.29	21.91
1400	52.10	65.93	13.83	26.54
1500	43.28	56.67	13.39	30.94
1600	28.87	39.92	11.05	39.37
1700	13.54	18.09	4.55	33.60
1800	+0.00	0.38	0.38	N.A.

* Dut to instrumental difficulties first portion of hour ending at 0800 was not recorded.

\+ No radiation observed on horizontal.

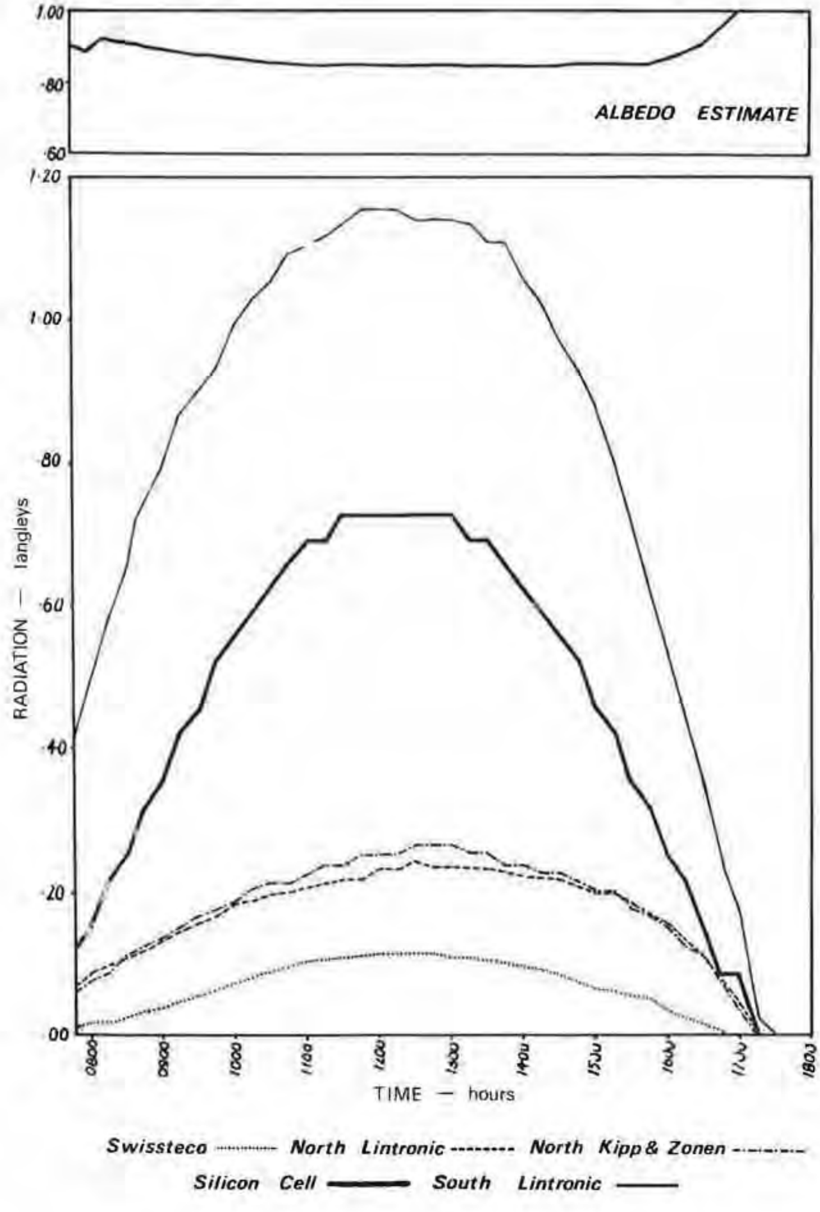

Fig. 2. Curves of radiation measurements taken at Macdonald College, February 23, 1976.

records. This average percentage was then applied to the data. Table Two illustrates the resulting breakdown of measured global radiation into its diffuse and direct components.

The data of Table Two were then used as input for a computer routine which calculated topographical variations. There is some debate as to the correct value of the solar constant which should be used in the computer programme adopted. The sensitivity of the algorithm to this parameter was investigated and it was found that no significant variation was introduced by changing the value of the solar constant from 1.96 ly/min to 2.00 ly/min. A value of 1.98 ly/min was used in the present study. Other sources of error in the computed results are instrumental and are well-documented in manufacturer's specifications. The temperature compensation of the instruments' calibrations were applied according to manufacturers' recommendations. Compensation factors can be found in Table Three.

The readings of the electrical potential generated by each instrument were taken at approximately fifteen minute intervals and hence represent instantaneous values. The integrated values were calculated by multiplying the instantaneous values by the sampling interval These values are entered in Table Four.

Results

The traces of various instruments, presented in Figure 2, appear to conform to the diurnal variation which could be expected for a clear February day. A slight instrument malfunction, due to the cold conditions prevailing in the early morning, is reflected in the irregular initial trace for the albedo estimate.

Table Four represents the hourly integrated values from the sensors. The radiation enhancement on the south wall has been calculated by subtracting the predicted maximum potential radiation on a south wall, as generated by the computer routine, from the observed radiation on the wall. The results are shown in Table Five. Since both the direct and diffuse components have been taken into account by the computer routine it can be concluded that the enhancement on the south wall is due strictly to forward scattering from the snowpack. This scattering is dependent on both the solar elevation (Zenith angle) and the conditions of the underlying surface. The latter must, in this case, be assumed to approximate the ideal situation of a new fallen powder snow surface. It can be noted from the data of Table Five that a negative radiation increment was observed in the early morning. This increment is due to instrumental difficulties which were encountered during the early phases of the experiment.

Conclusions

An examination of the values in Table Five shows that a substantial portion, 20% or more, of the radiation received on the south-facing wall is due to forward scattering from the snowpack. Increments of this order can make a considerable contribution to the total flux of solar energy available on such a surface. It is therefore highly recommended that due consideration be given in this area, to the contribution of forward scattering from snow surfaces, to the irradiation received on a south facing and other surfaces. This phenomenon could be important for scientists considering the design of a solar collection system and hence should be studied by both climatologists and engineers.

REFERENCES

Arnfield, A.J., 1975: "A Note on the Diurnal, Latitudinal and Seasonal Variation of the Surface Reflection Coefficient", Journal of Applied Meteorology, Vol. 14, pp. 1603-1608.

Dirmhirn, I. and F.D. Eaton, 1975: "Some Characteristics of the Albedo of Snow", Journal of Applied Meteorology, Vol. 14, pp. 375-379.

Latimer, J.R., 1971: "Radiation Measurement", International Field Year for the Great Lakes, Technical Manual Series, No. 2.

List, R.J., 1958: "Smithsonian Meteorological Tables", 6th rev. ed., Washington, D.C.

Ohmura, A., 1968: "Computation and Mapping the Shortwave Radiation on a Slope", M.Sc. Thesis, McGill University.

Robinson, N., (ed), 1966: Solar Radiation, Elsevier Publishing Co., 347 pp.

Sellers, W.D., 1972: Physical Climatology, University of Chicago Press, 272 pp.

A CLIMATOLOGIST IN THE SOVIET UNION

by

Marie Sanderson*

During the past year, I have twice visited the Soviet Union, this July to attend the 23rd International Geographical Congress in Moscow, and last September on an exchange of scientists program between the National Research Council (Canada) and the Soviet Academy of Sciences. On the latter occasion I visited Moscow, Yakutsk in Eastern Siberia and Tbilisi in Georgia over a three week period. This summer I visited Leningrad for a pre-Congress Symposium on Polar Lands, and Moscow, a week in each city. I thoroughly enjoyed each visit and found the Russian scientists, as well as casual acquaintances I met, most charming and unbelievably hospitable. Elsewhere in this Bulletin there is a note on the climatology program at the Congress, and the present report refers only to my Academy of Science visit.

It was very different travelling alone as a guest of the Soviet government from being a participant in a large Congress. In the first instance, everything was made easy since at all times I was accompanied by an English speaking interpreter. Geographers at the Congress who didn't speak Russian and had trouble with Intourist, will understand what I mean. Of course, there were disadvantages, too, since I had no English speaking friends with whom to compare impressions of the things I saw.

In my application to the National Research Council, which had to be approved by the Soviet Academy, I requested visits to Maria Gavrilova, at the Permafrost Institute in Yakutsk, F.F. Davitaya, of

---

* Marie Sanderson is Professor of Climatology in the Department of Geography, University of Windsor, Windsor, Ontario.

the Institute of Geography at Tbilisi, and M.I. Budyko of the Main Geophysical Observatory at Leningrad. All three were approved, but the Leningrad visit was cancelled while I was in the Soviet Union. For that reason, I was particularly pleased to visit Leningrad this summer, and again tried to meet Dr. Budyko with no success.

Last fall, my official visit began in Moscow where I stayed at the Academy of Sciences hotel, which is an adequate hotel but not as luxurious as the Intourist hotels like the Rossiya or Intourist. I left Moscow in the evening on an international Aeroflot flight for Pnom Penh, Cambodia. It stopped to refuel at Omsk and arrived at Irkutsk early the next morning - six time zones from Moscow. It was hard to remember that the flight was completely over land and totally over the Soviet Union. One knows academically that the USSR occupies one-sixth of the land area of the globe and that its east-west extent spans eleven time zones, but this knowledge is still not preparation for the vast distances encountered in travelling in the USSR. I spent most of my 22 hours in Irkutsk in the Intourist lounge at the airport, waiting for the flight north to Yakutsk. One aspect of air travel in the USSR that is unusual for foreigners is that all flights operate on Moscow time. This explains the surprise to learn that a flight leaves at 4 a.m. local time when one thought it would be a civilized 10 a.m.!

I had long wanted to visit the Soviet sub Arctic, and especially the Lena River valley since I have travelled and worked in the Mackenzie valley in Canada's Northwest Territories. I wanted to see the similarities and differences between the Canadian and the Siberian sub Arctic. I was looking forward to visiting Maria Gavrilova at the Permafrost Institute since meeting her at the International Congresses in India and Montreal. She is a native Yakutian and very proud of her northern heritage. She was at the airport to meet me that September day with the interpreter of the Institute, Elena Pankova, and the deputy-director, Petr Danelovtsev - with bouquets of flowers for me.

Yakutsk, at latitude 62°N, is similar climatically to Yellowknife in Canada's Northwest Territories, but while Yellowknife, the largest centre in the NWT has some 10,000 people, Yakutsk has 160,000. It is a much older settlement, having been founded in the early 17th century by Russian explorers in their eastward search for a route to the Pacific. It still has some colorful and beautiful old log buildings but many are being replaced by large characterless apartments. All the new buildings are built on piles sunk into the permafrost as they are in Canada's north, and the utilities are enclosed in utilidors. Unfortunately, most of the beautiful taiga has been cut down in the city itself - but the city is surrounded by the hemlock and birch forest - the "green sea" that is so beloved by the Siberian people.

I stayed at the Lena Hotel in Yakutsk, a very comfortable hotel that had triple doors and windows against the Arctic climate. For my first official visit, I was taken to the Permafrost Institute, Siberian Division of the USSR Academy of Sciences, to meet the Director, Dr. Melnikov, and some of the senior scientists to discuss my program for the following days. After the official introduction to the Institute, I saw Dr. Gavrilova's office, met her two smiling Yakut assistants (female) and discussed her current research. She explained that her main interest now is the relationship on a world-wide scale of permafrost to microclimate. I was also taken on a tour of the underground in-the-permafrost laboratories of the Institute where engineering research was being conducted. We were accompanied by Dr. Nina Anisimova, a charming grandmother who is a senior scientist at the Institute, working in permafrost hydrology.

My days were extremely busy. The schedule usually began right after breakfast, which I had with Lena in a private dining room in my hotel, and ended with dinner and dancing at someone's apartment in the late evening. One day in Yakutsk was spent in becoming acquainted with the city and its environs, its museums and its art. We first visited the Regional Studies museum, then the P.A. Oyunskiy Museum. (Oyunskiy is a Yakutian national poet-hero). We had lunch that day at Dr. Gavrilova's summer house in the pine woods outside the city. This house, although not the land, is privately owned and occupied by the Gavrilovas from May to the end of September. The senior scientific staff from the Institute were guests and the lunch was prepared by Dr. Gavrilova's husband and two cousins. After lunch, we went on a field trip, the scientists driving me around the vicinity of Yakutsk to see pingos, river terraces and thermokarst lakes, features similar to many I have seen in Canada's Northwest.

There were also films about Yakutian art in the Academy of Sciences building and it was obvious that this far northern community does not lack for culture, with a symphony orchestra, drama groups, folk dancing groups, all with a very pronounced Yakutian nationalist flavour.

On September 19th Yakutsk had its first snowfall of the season, and everyone appeared in fur hats and big boots. This was the day I visited many of the branches of the Siberian Division of the USSR Academy of Sciences, the Institute of Language, Literature and History, the Geological museum, and the Biological Institute. The directors of the Institute of Languages and the Biological Institute were women, and both impressed me very much. We went next to the botanical gardens but because of the snow, we did not tour the gardens but the greenhouses only. I was impressed by the greenhouses themselves, at 62°N, and by the enthusiasm of all the scientists, and other workers as well, in their attempts to improve plant species in this northern latitude and to brighten the long winters with flowers. We visited the University of Yakutsk where I met the members of the Yakutian branch of the Geographical Society of the USSR, and its president, Semyon Mostakhov. We had discussions about geographical education, but I was not able to meet any students since classes had not yet begun. The students, I was told, were in the rural areas helping the farmers with the potato harvest.

One day the Institute arranged a field trip for me to visit the Ordzhonikidsevskiy region and to have a trip on the Lena River. We went by car - over very bad roads - 100 kms south to the Pokrovsk settlement, a small village of about 4,000 people. Most of the houses were of the traditional brown wooden construction and the streets were unpaved. We met the Executive Committee of the region in the main administration building and I was surprised to find the Director, and Assistant Director, were women. They explained the activities in the region and their enthusiasm for its development was most apparent. Then we went by jeep to visit the agrometeorological station, and the botanical gardens. The station is very modern, well equipped and typical of all the meteorological stations I saw in the Soviet Union. At the botanical gardens I was shown an apple tree which has been developed to withstand the severe northern climate. One of my treasured gifts from Pokrovsk was a traditional Siberian wooden goblet inscribed to me, used for drinking kumiss, a local drink of fermented mare's milk.

The director of the Permafrost Institute had sent the Institute's research ship to bring us back to Yakutsk on the Lena River.

The river is extremely wide here and resembles the Mackenzie with its shoals and islands, but there is a great deal more traffic on the Lena. We passed many tugs with long lines of barges, with machinery, wood, oil drums, very much like the Mackenzie. A hydrofoil went by at high speed and many smaller boats were in evidence. My hosts told me that they spend many weekends in canoeing down the river in the summer. Lena and her husband had canoed 1200 miles down the river to the Arctic coast - and I told her that people do the same on the Mackenzie. The captain, who had graduated from a navigation school in Omsk, showed us the very excellent, detailed charts of the river which he used. He said that he liked life on the river and was looking forward to next year when he would have a television set in the wheelhouse. On my last night in Yakutsk, the Deputy Director had a farewell dinner in his apartment, then everyone at the party escorted me to the airport for my departure - at 4 a.m.! I had no idea when I left Yakutsk that in a few months time I would meet these wonderful people from the Permafrost Institute in Leningrad!

The return trip to Moscow took 21 hours and was completely exhausting. I also found that the poorly pressurized aircraft caused my ears to hurt and left me deaf for several days. However, even in the very busy airports and very crowded aircraft, I found that foreign tourists were treated as first-class passengers. The friendliness of the ordinary Russian people to the stranger in their midst, especially one who couldn't speak a word of Russian was something never to be forgotten.

I left Moscow again for Tbilisi - 1400 miles south east, in the republic of Georgia. I was to visit F.F. Davitaya and the Institute of Geography there. I had known Dr. Davitaya from other geographical meetings, and from his work in agrometeorology and climatic change. He is also a vice-president of the IGU and was one of the organizers of the Congress. Of course, I was delighted to meet him in Moscow at the Congress in July. Again, I was aware of the extraordinary size of the USSR and its different climates when I was transported from the sub Arctic into the typical Mediterranean setting of Tbilisi. Tbilisi has a beautiful location on the Koura River between two ranges of the Caucasus Mountains. The Georgians often refer to their republic as "Trans Caucasia". The city has more than one million inhabitants, and has a history of more than 2000 years. This republic is certainly not typical of the "endless Russian steppes". It looks and feels Mediterranean with the semi-arid vegetation, the red tiled roofs of the buildings and the dark Georgian people. Dr. Davitaya and one of the Institute interpreters, Tina Gabrichidze, met me at the beautiful Tbilisi airport and took me to the Iveria Hotel, a very modern and pleasant hotel with a beautiful view of the Koura valley.

I was in Tbilisi for eight days and each day was crammed with activity. I was usually picked up each morning about 9 a.m. by Dr. Davitaya and Tina with an Institute car and driver. However, on several occasions one of the scientitst would call for me with his own private car - usually a proud recent acquisition. We toured the environs of Tbilisi and its historic sites and visited cathedrals and castles as well as scientific institutions.

I spent one day at the Vakhushti Institute of Geography of which Davitaya is director. As a Canadian geographer I could not help noticing the high status of geography in the Soviet Union and the great number of geographers who are engaged in research. The Institute of Geography in Tbilisi had some 300 employees and 60 research scientists. There is, obviously, a very applied stress in the research activity. There are 11 sections in the Institute, geomorphology and paleogeography, quarternary geomorphology, climatology and hydrology, landscape study, speliology, economic geography, population and settlement, coastal geomorphology, cartography, aeroscience and glaciology. Although none of the heads of sections were women, I met five female scientists at the Institute.

I also visited the Geophysical Institute, the Cloud Physics section where we were met by the Director, Dr. Kartsivadze, and several of the senior scientists. I was shown the various cloud chambers and informed of the theoretical part of their work in hail suppression. They are experimenting with different types of reagents to disperse the hail since they stated that silver is too expensive and lead is toxic. We toured the Gravimetric Institute, a part of the Institute of Geophysics, a newly-established (1967) institute where work in the measurement of earth tides is going on.

On another day, we visited the University and the Geography Department. It is housed in a beautiful red building in downtown

Tbilisi, and I met the Professor of Hydrology, Dr. G.G. Svanidze and several of the staff. However, I was sorry that I was not invited to any of the classes or to meet the students. They informed me that they have 400 students majoring in geography. Dr. Svanidze spoke of his work in hydrology, and has since sent me several of his books on this topic. After a visit to the University climate station, we drove to one of the Institute's hydrologic stations a few miles out of Tbilisi. Here I again met the scientific staff and observed their method of measuring the flow of a branch of the Koura River, and visited the teaching facilities at the field station. It is very efficiently set up, and well instrumented, as was the climate station at the University. I also visited the Hydrometeorology Institute, where Dr. Davitaya had worked as a weather observer, as had another well known Georgian - Joseph Stalin!

One of the most interesting days in Georgia was the one spent in visiting Kaheti province and the hail suppression field station. This meant a 200 km drive, but a most interesting one, eastward from Tbilisi into the main wine producing area in Georgia. The director of the Institute of Geophysics, Dr. Dartsivadze met us here, and we sat in on the daily briefing with his scientific staff of about 30. The hail suppression program in Georgia is a large one, involving some 500 people and the main control field station is a very impressive set of buildings. This is the main control centre for the 50 rocket installations which form the main hail defence program. Evidently, some 60-70 hail storms are recorded each year in this Kaheti region. We visited the ozone laboratory on the station, and the meteorological office, before being taken by the Director on a tour of the local area. Dinner was served in a rustic log cabin back at the station, with the shashlik being roasted over the open fire. About 20 of the scientitst attended the dinner, and it was obvious that they were a very closely knit, enthusiastic group of scientists, and convinced of the value of their work. Actually, I would like to have heard more of the efficiency of the cloud seeding and how the results were measured. The cost of the hail suppression program to the State must be enormous, but to the Georgians, grapes and wine are very important commodities. They would consider no cost too great to ensure production of their famous wines, and after tasting a good many of them, I am inclined to agree.

My three weeks in the Soviet Union was an experience I shall never forget, especially the unbelievable friendliness and hospitality I received. I was most impressed with the development of the sub Arctic in Yakutia, and the enthusiasm with which the northern scientists are coping with the difficult problems of the environment. I was also impressed with the scientific attempts in Georgia to "transform Nature", for the benefit of man. The obvious loyalties of the researchers - and other staff - to the directors of the various institutes was most pleasant to see.

As a woman, I was of course most impressed with the number of female scientists as well as administrators of various kinds whom I met. They were astonished to hear of the few female scientists there are in Canada. The exchange of scientists program between the National Research Council and the Soviet Academy of Sciences has as its purpose the exchange of scientific information. It accomplishes this but also, and perhaps more important, it fosters goodwill and friendship between the scientists of our two countries.

RECENT DOCTORAL THESES IN CLIMATOLOGY

The list given below comprises recently completed doctoral dissertations in climatological subjects which may be of interest to readers of the Climatological Bulletin. The list has been compiled from three sources:

(a) "Recent Geography Dissertations and Theses Completed", compiled by Michael R. Hill and Robert H. Stoddard in The Professional Geographer, Vol. 28, No. 1, February, 1976, pp. 71-93;

(b) "PhD Degree Recipients and Dissertation Titles, September, 1973 - August, 1974", Bulln. Amer. Meteor. Soc., Vol. 56, No. 4, April, 1975, pp. 473-476; and

(c) "List of Theses and Dissertations on Canadian Geography", compiled by J. Keith Fraser, 1975 Supplement, Canadian Committee for Geography, Ottawa, 1976.

Bridge, Daniel W. "A Simulation Model Relating Effective Climate to Spring and Winter Wheat Yields on the Northern Great Plains." Southern Illinois University, Carbondale, 1975.

Cogley, J.G. "Properties of Surface Runoff in the High Arctic." McMaster University, 1975

Fitzharris, Brian B. "Snow Accumulation and Deposition on a West Coast Midlatitude Mountain." University of British Columbia, 1975.

Harlin, John M. "Climatic Variability and Its Influence on Basin Morphometry." University of Iowa, 1975.

Hewings, J.M. "Environmental Indices and Public Attitudes: The Case of the Ontario Air Pollution Index." Toronto University, 1975.

Huckabay, James. "An Urban Atmospheric Disruption Index Set for Mid-western Cities." University of Kansas, 1975.

Jenner, Carol B. "Modelling the Effect of Land Use on the Urban Temperature Fields." University of Maryland, 1975.

Klink, John Curtis. "A Global Solar Radiation Climatology for Minneapolis-St. Paul." University of Minnesota, 1974.

Kyle, J. William. "Spatial and Temporal Variation in the Distribution of Radiation in a Mature Corn Canopy." McMaster University, 1974.

Munro, D.S. "Energy Exchange on a Melting Glacier." McMaster University, 1975.

Newton, John. "The Canada Basin; Mean Circulation and Intermediate Scale Flow Features." University of Washington, 1974

Numez, Manuel. "The Energy Balance of an Urban Canyon, Vancouver, B.C." University of British Columbia, 1974.

Pendergast, Malcolm M. "A Study of the Effects of the Urban Meso-Climate on Local and Regional Pollution Potential in South-east Texas," Texas A & M University, 1974.

Potter, Gerald L. "Anthropogenic Climate Modification: Modeling the Removal of the Tropical Rain Forest." University of California, Los Angeles, 1975.

Price, Anthony. "Snowmelt Runoff Processes in a Sub-Arctic Area." McGill University, 1975.

Sengenberger, David L. "Climatic Year Regions of the Western Great Lakes States." University of Oklahoma, 1973.

Stewart, R.B. "The Evaporation from Three High Latitude Surfaces." McMaster University, 1975.

Topps, Keith. "Diurnal Variations of the Urban Heat Island." University of Kansas, 1975.

Yoshioka, Gary A. "A Simulation Study of Urban Albedo." John Hopkins University, 1975.

NEWS AND COMMENTS

The following report is contributed by David Phillips of the Atmospheric Environment Service who was the "Climatologist in Orbit" for 1975-76 associated with the informal group of Friends of Climatology:

"Splashdown occurred on the 20th of April, 1976, at 2035 GMT, after 99 days, 1 hour, and 16 minutes in space and three new world records. According to Guinness this marked the longest manned space flight, the most accurate return (Room PS105, University of Guelph), and all for somewhat less than the 26 billion dollars spend on the U.S. manned space program to date.

It all began on an overcast, snowy day in January. The launch vehicle, AES I, was rocketed into space at 1500 GMT. It was a smooth take-off, and, after a small mid-course correction, I was well on my way with a mission to visit 13 Ontario campuses and deliver 20 lectures. In all, I travelled 4000 km, met 903 students, gained 4.5 kg, and temporarily grew 3 cm in stature.

Prior to blast-off and on the day the postal strike ended, I had mailed to 17 campuses in Ontario and Quebec abstracts of three presentations: Consulting Climatology in Environment Canada; IFYGL - Scientific Information for Great Lakes Decision Makers; and Environments of Canada - A Sound and Slide Presentation.

My first mission was a pass over Toronto to Scarborough College of the University of Toronto. There, I met a very busy Chris Sparrow and spoke to his second-year climatology class. The first questions asked were: "How much money do you make?" followed closely by, "Are there any jobs available?" A short sub-orbital flight brought me to downtown Toronto and the St. George Campus of the University of Toronto. My audience this time was G. Szeicz's second-year Climate and Environment. Again, questions relating to job opportunities and environmental priorities dominated the question period.

During February I visited four campuses. In Kitchener-Waterloo at Waterloo Lutheran University, Jerry Hall asked me to speak to his third and fourth-year class of geography students. After my lecture on consulting climatology, we adjourned to the campus pub for a lengthy question period. The next day I managed somehow to travel one mile along the orbital path to the University of Waterloo. The weather that day was mostly sunny and cold, although being in the Department where Geoff McBoyle is Head, I more properly should say that for most of the day the sky had less than 7/10 cloud cover except for periods totalling 3 or 4 hours when it had 7/10 or more. I lunched at the beautiful Waterloo Faculty Club, to which few can afford to belong and then toured the Faculty of Environmental Studies with Jim Gardner. In the afternoon I spoke to a mixed group of graduate students and faculty on consulting climatology.

During the second week of February I rocketed eastward to Trent and Queen's. I followed the Otonabee River north of Peterborough, looking for the only campus drumlin in North America. I knew I had reached my first landing site when I spotted the Geography Department vehicle, a well-known landmark at most southern Ontario geography gatherings. I have two complaints about my extra-vehicular activity (E.V.A.) at Trent: the early-morning lecture hour which necessitated a start around 1030 GMT and secondly the fact that Peter Adams took 10 minutes of my 50-minute lecture time to make announcements about future campouts, survival courses, exploration tours, digs, drills, and time to reserve seats in his geography van for a lecture in Toronto.

Things did not go well at Queen's. Besides burnt-out projector bulbs and short extension cords, I happened to miss a dinner reservation, locked my keys in my command module and booked into a motel while reservations had been made for me on campus. In the evening I lectured to Harry McCaughey's extension class on applied climatology and the next day spoke to a small group on IFYGL. In spite of these misfortunes, I had an enjoyable E.V.A. in Kingston, expecially the post-lecture gathering at the Faculty Club with members and wives.

In March I travelled to four universities. On the 1st, it was off to St. Catharines and Brock University. There I met Jan Terasmae of the Geological Science Department, who had arranged the lecture - to only three students in a room which seated hundreds! It seems that students and faculty had not yet returned from a field trip to the Grand Canyon. With only one month left and scheduling tight, I pressed on to Guelph in spite of a collection of extraterrestrial illnesses inherited along the way. I arrived armed with a number of cold remedies and an atomizer, since I was to deliver three lectures in four hours. At Guelph I found my way to Murray Brown's office and during the day toured the Department of Land Resource Sciences. Unfortunately, time did not permit a similar tour of the Geography Department, although it was pleasant to lunch with Jackie Wolf and Bill Day.

During the middle of March, I landed at the doorstep of York University. There I met Ted Spence and Don McIver and spoke to a combined class of hydrologists and climatologists. I had difficulty seeing the students that day because of all the construction scaffolding in the room. Apparently, the staff were concerned that the ceiling might collapse at any moment. A return trip to the downtown core of Toronto was my next destination. Located one block east of the Yonge Street strip is the urban campus of Ryerson Institute. This was the first time a CIO had visited this school, and I must say I was very impressed with their program and the emphasis on the application of geographical knowledge to real world problems.

A quick shuttle deposited me at Hamilton's McMaster University, my next scheduled E.V.A. While at Mac I was entertained by Frank Hannell and lunched with several students who were anxious about career opportunities in climatology. My only regret is that I had so little time to talk with John Davies and Wayne Rouse.

My final orbit was over southwestern Ontario with shuttles to Windsor and Western. It was the first time in four lecture visits to Windsor that I had a chance to visit with Marie Sanderson and enjoy her vivid account of how she was able to stomach a constant diet of Russian horsemeat and fermented mare's milk. I spoke to a gathering of 200 first-year students of John Jacobs. If only Bob Packer's room number was the same as his phone number I would not have been ten minutes late for my lecture at Western. There I spoke to a combined class of second-year and fourth-year geography students on IFYGL and was challenged with some interesting questions. I especially enjoyed my tour of their spacious and well-equipped map library and have since informed our AES librarians where they can get old weather maps.

In conclusion, like others who have orbited before me, I strongly endorse the idea of a climatologist-in-orbit and recommend its continuence in the futhre.

I wish to thank Morley Thomas and Lloyd Richards of Mission Control for making a good management decision and granting me permission to go into orbit; and my staff, whose beliefs were confirmed that I am not really down to earth. Finally, to my thirteen hosts and many friends, new and old, my gratitude for making my visit an enjoyable and lasting experience."

Professor B.J. Garnier attended the conference on Mountain Meteorology and Biometeorology held in Interlaken, Switzerland from June 10-14, 1976, organised jointly by the Swiss Geophysical Society of Balneology and Bioclimatology, and the American Meteorological Society. He presented a paper entitled "The Calculation of Topographic Variations in Solar Radiation in Mountain Regions". Other Canadian contributions to the conference were from P. Schüepp "On Aerodynamic Prediction of Terrestrial Heat and Water Vapor Losses", P.F. Lester "Mesoscale Characteristics of the Alberta Chinook", and N. Barthakur "Use of Microwave Radiation to Study Plant-Environment Interactions."

John E. Lewis, assistant professor of climatology at McGill University, attended the 23rd congress of the International Geographical Union in Moscow from July 27 to August 3, 1976. He presented a joint paper with S.I. Outcalt entitled "Verifying an Urban Surface Climate Simulation Model."

A recent publication of interest to applied climatologists is "The Tourism and Outdoor Recreation Climate of the Maritime Provinces" by A.D. Gates and published by the Meteorological Applications Branch of the Atmospheric Environment Service.

A two-day Workshop on Remote Sensing was held at McGill University on May 13 & 14, 1976. A total of six discussion papers were presented with emphasis on remote sensing technology and its practical applications. Speakers and their subjects are given below.

1. "Summary of Sensor Technology - Multi-spectral Scanners"
   Neil de Villiers - Canada Center for Remote Sensing.
2. "Surface Energy Exchange Climatology - Thermal Application"
   Sam Outcalt, University of Michigan.
3. "Multi-spectral Imagery with Application to Hydrology"
   Al Rango, NASA/Greenbelt.
4. "Remote Sensing of Soil Moisture"
   Josef Cihlar, Canada Center for Remote Sensing.
5. "Landform Analysis, with Imaging Radar"
   Anthony Lewis, Louisiana State University.
6. "Microwave Sensing of Sea Ice"
   Rene Ramseier, Department of Environment.

Climatology, Hydrology, and Glaciation formed one of the several sections of the program for the 23rd congress of the International Geographical Union held in Moscow from July 27-August 3, 1976. Within this section climatology was well represented with approximately 34 papers presented in three separate sections and if the section on Maps and Records in Climatology and Hydrology are added the total becomes 49 papers. Section sub-titles within climatology were: 1) General Problems of Climatology; 2) Climatic Variations; and 3) Man-made Impact on the Atmosphere. Examples of papers in the first session are: Munro, D.S., and J.A. Davies, "Diurnal Energy Flux Variations and Glacier Surface Hydrology" and Yoshimo, M.M. "Bora Regions in Yugoslavia"; for the section on climatic variation, Shikhlinskii, E.M. contributed "Earth Climate as the System of Mobile Equilibrium". The session on "Man-made Impact" was a very lively one. Among the papers presented in this session were Budyko, M.I. and F.F. Davitaya, "Man's Impact on Climate"; Bridgman, K.A., "The Influence of Urban Pollution on the Spectrum of Direct Visible Radiation" and Lewis, J.E. and S.I. Outcalt, "Verifying an Urban Surface Climate Simulation Model."

Michael H. Glantz of the NCAR, Boulder, Colorado, has been commissioned by the International Federation of Institutes for Advanced Studies to investigate the impact on society of reliable long-range climatic forecasts. His particular topic of investigation will be "Grazing in the Sahel, 1973" about which he has already completed a preliminary assessment; and "Spring Wheat in Canada, 1974" on which he has produced a case study for Saskatchewan.

McGill University

Department of Geography

CLIMATOLOGICAL RESEARCH SERIES

No. 1 Two Studies in Barbadian Climatology, by W.R. Rouse and David Watts, 65 pp., July 1966, price $6.50

No. 2 Weather Conditions in Nigeria, by B.J. Garnier, 163 pp., March 1967, out of print.

No. 3 Climate of the Rupununi Savannas - A Study in Ecological Climatology, by David B. Frost, 92 pp., December 1967, price $8.50.

No. 4 Temperature Variability and Synoptic Cold Fronts in the Winter Climate of Mexico, by J.B. Hill, 71 pp., February, price $7.50.

No. 5 Topographic Influences on a Forest Microclimate, by R.G. Wilson, 109 pp., September 1970, price $10.00.

No. 6 Estimating the Topographic Variations of Short-Wave Radiation Income: The Example of Barbados, by B.J. Garnier and Atsumu Ohmura, 66 pp., December 1969, price $7.50.

No. 7 The Remote Sensing of Surface Radiative Temperatures Over Barbados, by B.J. Garnier, 52 pp., May 1972, price $6.50.

No. 8 Moisture Conditions in the Savanna Region of West Africa, by Kala Swami, 106 pp., December 1973, price $8.50.

No. 9 Solar and Net Radiation Over Snow, by D.E. Petzold, 77 pp. November 1974, price $7.50.

Prices of Research Series vary, but subscribers to the Bulletin are entitled to a 50% reduction on the published price, provided they hold or held a current subscription for the year in which the relevant number of the Research Series appears. Send orders and inquiries to:

Department of Geography (Climatology)
McGill University
P.O. Box 6070, Station A
Montreal, Quebec, Canada
H3C 3G1

Lithographed in Canada by Forrest Lithographing Limited, Montreal, Quebec.