RICHMOND LONGLEY AND CLIMATIC VARIABILITY IN CANADA

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Richmond (Dick) W. Longley showed his interest in climate change and climate variability on a number of scales over a period of 40 years. One of his first published papers (Longley 1942) looked at the frequency distribution through the year of abnormally high and low daily mean temperatures at Toronto comparing them with a similar study at Greenwich, England, whereas one of his most recent contributions (Longley 1979) was an analysis of minimum temperatures in the Canadian Arctic.

Following his 1942 paper based on Toronto temperatures, he examined standard deviations of the mean daily temperature at 18 stations throughout Canada (Longley 1947). All stations had 50 or more years of record except Sable Island, Churchill, York Factory and Dawson. In this study, Longley calculated standard deviations for 48 days in the year on the 5th, 13th, 20th and 28th of each month, and showed, as expected, that winter temperatures were more variable than summer, and that maritime stations were less variable than continental stations. Changes from winter to summer, and vice versa, were shown to occur abruptly rather than gradually. Later he published (Longley 1951A) on the daily variation of temperature at 19 stations across Canada, and on differences of the temperature extremes at stations in the Montréal Forecast Region (Longley 1951B).

The first thorough study of temperature trends in Canada[2] was conducted by Longley (1954B): it dealt with temperature cycles in 14 geographical districts of Canada based on data from 61 stations. This was a contribution to a climatic change panel discussion at the Toronto Meteorological Conference in September 1953. It is worth mentioning the results. In all districts in which records went back to 1880, the decade of the eighties was cold, with warming occurring thereafter. There was considerable variation between districts.

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2 Ed. note: For a more recent study of temperature changes in Canada see Berry (1981).

The warmest decades were generally those ending in the 1930s, though in the east the warmth continued until the late 1940s. By the late 1940s western Canada was definitely cooler. An elaboration of this study (Longley 1954A) summarized mean annual and 10-year running mean temperatures for the 62 selected stations for their period of record and values for the districts in which they were grouped.

Longley's (1958) studies of temperature fluctuations at Resolute, Northwest Territories included 7-day running means for 8 years of data, which showed fluctuations in mean daily temperatures of about 16 days - an average in good agreement with a more recent, broader study of 10 Canadian stations by Strong and Khandekar (1975). More recently, Longley (1979) extended his earlier study at Resolute to analysis of minimum winter temperatures at 20 stations in the Canadian Arctic from 1941 to 1977. He found that, on the average, the lowest temperature advances from south of the Arctic Circle in late January to the northern part of Ellesmere Island in the first week of March.

In 1967, Longley published a stimulating paper on changes in the frost-free period in Alberta. In it he compared the mean frost-free period for 1951-1964 with the years prior to 1951 for 68 stations grouped by river basins. In southeastern Alberta the increase in the frost-free period for the latter period was small, but stations in the North Saskatchewan River Basin showed increases of one full month, and several other areas two to three weeks. As frosts are associated with minimum temperatures in spring and fall, he examined 10-year running mean trends for these seasons at selected stations for periods of 50 years or more. This interest in frost data had been kindled earlier by his involvement in a climatic summaries publication (Boughner *et al.* 1956), which included an introduction on the frost-free season in Canada.

Longley also published extensively on variability of precipitation. Two early studies in this area (Longley 1952, 1953B) showed that the coefficient of variation was the best and most stable measure of variability of precipitation. The first paper used 30 British Columbia stations and four stations from neighbouring Washington with records of at least 30 years to test the relationship between precipitation and variability, developing coefficients of variation for July, December and annual precipitation totals. The second involved a wider geographic sample using annual precipitation totals for 142 stations across Canada and 34 in the adjacent areas of the United States based on the period 1900-1950.

Generally, minimum variability increases as one moves poleward. Variability is greatest in the central Prairies and least in the Maritimes, whereas the pattern in the mountains and valleys of British Columbia is irregular. In addition, Longley (1953A) investigated the length of dry and wet spells using data from Dawson, Victoria, Winnipeg, Montréal and St. John. He found that after a wet day the probability of the following day being wet is constant no matter how long the wet period has persisted. The same is true following a dry day except there is a slight increase in the probability of dry weather with increasing length of the dry period.

Twenty years later he produced another series of papers on precipitation. In a study dealing with the Canadian prairies, Longley (1972B) returned to the question of the length of wet and dry spells in the summer months based on studies of 21 stations divided equally between the three provinces. He also looked at the relationship between precipitation and distance to determine the extent to which rain at one location implies rain at another, using 24 stations largely in Alberta for the analysis. Variation of precipitation through the years of record was also analysed based on 10-year running mean annual precipitation for five river basins. The method had been used in "The Climate of the Prairie Provinces" (Longley 1972A), but in this case he stressed the need for care in the selection of stations to represent average values for a river basin. In the case of the Assiniboine River Basin, he showed that the major cause for the changes in annual precipitation during the previous 50 years was variation in the summer months. A paper (Longley 1974) on spatial variation of precipitation over the prairies through the period of record demonstrated that trends in precipitation are not the same throughout the main agricultural area of the Prairie Provinces. This conclusion was supported by correlation coefficients between precipitation amounts at pairs of stations and the particular direction in which storms move across the prairies, which varies from month to month during the summer season. He showed that a significant correlation exists between the monthly precipitation of two stations on the prairies when the distance between them is less than 400 km, and that the correlation is greater when the stations are east and west of each other, than when they are north and south of each other. In two papers (Longley 1973, 1975) he discussed the effect of prairie valleys on precipitation, finding that precipitation in a valley is 10 to 20% below that on the surrounding plain.

In his publications on local climate, or in his textbooks, Longley usually included a section on climatic trends or change. For example, in "The Climate of Montreal" (Longley

1954C) he gives mean departure from normal for 10-year periods for mean annual temperature, annual rainfall, and seasonal snowfall from 1880 to 1950. The trends were found to be similar to those of western Europe for the same period, and he mentions the trends in Europe for the preceding 150 years.

The textbook "Elements of Meteorology" (Longley 1970) contains a whole chapter on climatic change, and it is here we note his interest in the entire subject as he discusses likely causes for change - the solar constant, albedo, long-wave radiation.

"The Climate of the Prairie Provinces" (Longley 1972A) includes part of a chapter on climatic change, with regional examples for temperature and precipitation. In this study, he shows mean annual temperature for the Prairies south of 55°N rose about 0.8°C from the late 1800s until about 1910. From 1920 to 1950, the mean stayed between 2.8 and 3.3°C - the warmest decade being 1925-1934. The years 1945-1960 were generally cold with a minimum of 2.2°C for the decade ending in 1956, since when the 10-year mean has risen as high as 3.0°C in 1961. The study of the oil sands area in Alberta (Longley and Janz 1978) includes discussions of annual temperature trends at Fort McMurray, and the use of this station to estimate areal temperature distributions.

A contract study (Longley 1977) examined climatic change as it affects Alberta and the other Prairie Provinces. This included comments on ancient and recent temperatures from various sources, before providing details of temperature and precipitation changes (especially for the growing season) on the prairies since records began in 1872 at Winnipeg. The study includes a section on trends in minimum temperatures and changes in the length of the mean frost-free period for a number of stations. Lacombe, for example, had a mean frost-free period of 62 days for 1908-1917, and of 98 days for 1941-1970.

In addition to these published contributions to our understanding of climate variability in Canada, Longley also sparked the interest of others in the subject. He taught meteorology to new recruits for the Canadian Meteorological Service in Toronto during World War II. Then, for over a decade beginning in 1959, he taught meteorology at the University of Alberta. During this period, many of his students wrote term papers on climatic variability, and some prepared theses on the topic under his guidance. Richmond Longley contributed significantly to our knowledge of Canadian climate, and he was a Canadian pioneer in the study of climate variability using the instrumental record. In reviewing the first volume of this series just before his death, Longley (1981) concluded with the

sentence, "One can only wish the research staff of the National Museum every success with a project that promises to become the definitive work on climatic change in Canada."

The above discussion provides some highlights of Longley's many studies concerning climate variability. A biographical sketch listing all of his publications in meteorology up to 1977 is included in the special volume to honour him on the occasion of his 70th birthday (Hage and Reinelt 1978). In order to complete their list, I have included more recent publications in a separate section after the normal references.

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