
Changes in the Canadian Definitions of Break-up and Freeze-up

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ABSTRACT

Canadian definitions of break-up and freeze-up are shown to have changed substantially on several occasions since 1957. This paper demonstrates that because of these changes, great care must be exercised in the tabulation and interpretation of dates of

break-up and freeze-up. In part, these changes have been occasioned by historical concerns, so that scrupulous attention to definition is necessary if the Canadian record is to be used for scientific purposes.

1 Introduction

The processes of break-up and freeze-up have a serious impact upon the rhythm of life in Canada and, within the past two decades, there have been vigorous efforts to record and publish their dates of occurrence. In 1970, when all available Canadian dates of break-up and freeze-up were transferred to punched cards, dates were available from 472 locations on water bodies throughout Canada (Allen and Cudbird, 1971). Admittedly, the majority of these yielded short records, but a substantial number spanned several decades. Up to and including the 1969–70 ice season, 54 per cent of the records were of 10 years or less duration, but 87 records of break-up or freeze-up exceeded 20 years, 18 exceeded 50 years and 2 exceeded 100 years duration. The published dates, however, are extremely variable in quality and this is a problem which should be thoroughly appreciated by all users of these records. Although a multitude of factors can influence the homogeneity of records of this nature (Singh, 1973), a major part of the problem lies in the difficulty of defining precise events in the physically complex process of freezing and breaking.

2 Freezing and Breaking

The process of freezing is initiated by the first formation of ice and is completed when the ice cover achieves its maximum extent and thickness. Likewise, breaking begins with the first movement, mechanical fracturing or melting of ice and terminates when the water surface becomes ice free or when it achieves minimum ice coverage. In Canada the mean durations of the break-up and freeze-up processes on approximately 60 rivers is 10.0 days and 18.7 days respectively (Allen, 1964). The mean maximum durations of break-up

and freeze-up of these rivers are 19.5 and 36.7 days respectively. These ranges indicate a very considerable latitude for discrepancy among dates observed using different criteria. The dating procedure envisages breaking and freezing as occurring at moments in time whereas in fact they are quite lengthy intervals which, although continuous and accumulative, can be temporarily halted or reversed.

3 Definitions

Inevitably the definition of these moments in time is an arbitrary procedure and, for this reason, no universally satisfactory definitions of break-up and freeze-up have been formulated. Indeed, this problem of definition has not been resolved on a national scale within Canada, notwithstanding considerable effort on the part of the Meteorological Service in a sequence of four publications on break-up and freeze-up issued between 1957 and 1971.

Since 1950 (Canada, Meteorological Division, 1950), the Meteorological Service has been active in standardizing and improving the quality of break-up and freeze-up observations throughout Canada. Although laudable, these endeavours to improve the observational network have led to substantial and frequent changes in the criteria used to define break-up and freeze-up. Since some of these changes identify significantly different moments in the prolonged processes of freezing and breaking, many of the published dates in the Canadian record are for this reason lacking in homogeneity or comparability. Fig. 1 summarizes the essence of these changes. The following elaboration of definitions, however, is essential to convey in specific terms the nature and impact of these changes.

In the first publication (Burbidge and Lauder, 1957) break-up was "... considered to be the date when the ice moves in a river or clears from the shores of a lake." Freeze-up was defined as "... the date when ice forms and begins to grow, but may sometimes be listed as the time when skim ice or slush ice first forms. In the opposite extreme, some observers do not believe that the 'freeze-up' is official until the ice is thick enough to walk on with safety." Thus, in the 1957 publication there were three definitions of freeze-up and one of break-up. There was no tabulation of dates but average dates of freeze-up and break-up were presented on maps.

The second publication (Canada, Meteorological Branch, 1959) afforded the first official tabulation of dates of freeze-up and break-up in Canada, publishing observations from 217 stations. It recognized two dates of break-up and two dates of freeze-up. In the tabulations of dates of break-up, "... two dates are normally given. The first date refers to the first appearance of breaks or movement of ice and the second to the complete clearing of ice from the water." Likewise, in the list of dates of freeze up, "... two dates are normally given. The first refers to the first appearance of ice in the fall, and the second indicates the dates of complete ice coverage." In this publication no attempt was made to reconcile the definitions presented with those published in 1957, but the relationships between the two are illustrated in Fig. 1.

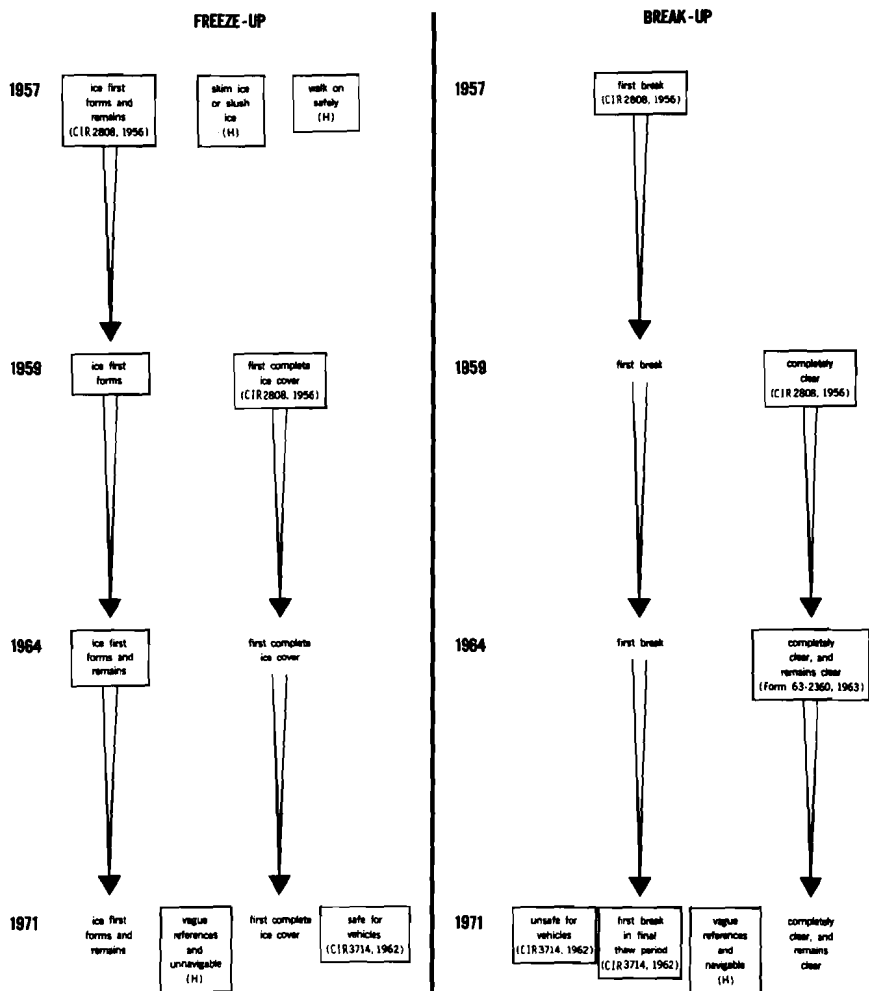


Fig. 1 Definitions of break-up and freeze-up in publications of the Meteorological Service. Arrows link definitions which are similar in class, although not necessarily identical in all their characteristics. New or changed definitions are enclosed in rectangles. When these changes relate to an earlier instruction to observers, the reference to the circular containing that instruction is in parenthesis. H indicates those new or changed definitions which apparently accommodate early, unstandardized observational criteria.

In the third publication (Allen, 1964), which contained both tables and maps, and presented dates from 328 water bodies, the definitions of freeze-up and break-up presented in 1959 were elaborated. Break-up was defined as:

“... commencing when the ice in a river or lake begins to move, break, or deteriorate; and ending when the water is completely free of all ice. The first date (1) given in the table, therefore, marks the beginning of the process.

In the case of rivers, it is usually evidenced by a definite breaking or movement of the ice brought about by weakening of the ice due to initial melting, currents, and a rise in water level due to runoff. ... The second date (2) under 'Break-Up' is the date on which the body of water is first observed to be entirely clear of ice and remains clear thereafter."

The 1964 definition of break-up (1) differs from that of 1959 only insofar as deterioration, as well as breaking and movement, is used as a criterion in establishing this date. Therefore, the direct manifestations of thermal as well as mechanical processes are considered to initiate break-up. A much more significant change occurred in the definition of the second date of break-up in the 1964 publication. Where previously break-up (2) was simply the first complete clearing of ice from the water surface, in 1964 it was stipulated that break-up (2) is the date when the water first becomes clear of ice and remains clear thereafter (Fig. 1).

In the same publication freeze-up was:

"... thought of as a process extending over a period of days or weeks. It commences with the appearance of ice crystals on the water surface, and ends when the body of water is completely frozen over. ... The first date (1) given under 'Freeze-Up' is the date on which ice was first observed on the water surface, and remained thereafter. ... The second date (2) given under 'Freeze-Up' is the date of freeze-over, i.e. the date on which the water was first observed to be completely frozen over."

These definitions of freeze-up differ in only one respect from those of the 1959 publication. Freeze-up (1) is further qualified as the date when ice first develops and remains thereafter. Since this criterion of permanence is only applied to freeze-up (1), it is conceivable that in a particular year freeze-up (1) may be recorded on a later date than freeze-up (2), although this does not appear to be the intent of the classification. This inconsistency does not arise in the case of the 1964 break-up dates because the criterion of permanency is applied to break-up (2).

The final publication (Allen and Cudbird, 1971) substantially modified the definition of break-up and freeze-up, and listed new criteria by which breaking and freezing were dated and tabulated. The previous definition of freeze-up (1) was essentially unchanged and given as the date "... on which new ice first formed on the water surface and did not melt completely again until its final deterioration during break-up of the following year." The term freeze-up (1) was abandoned in favour of "first permanent ice." Likewise, freeze-up (2) was renamed "complete freeze-over," although the definition as "... the earliest date on which the water body was reported to be completely covered by ice ..." was essentially the same. Thus, the possible reversibility in the chronological occurrence of the two freeze-up dates was not eliminated in 1971.

Break-up (1) was renamed "first deterioration of ice" and was redefined as: "... the earliest date during the final thawing period of the winter season

(if more than one occurred), on which there were definite indications that the ice was beginning to melt. This date marks the beginning of the break-up process, which may be manifested by a definite movement of the ice or the formation of cracks, leads or open water areas in the ice, all the result of weakening of the ice due to melting. On most lakes, where there is very little current to move the ice, initial evidence of melting may be the formation of pools of melt water on the ice surface."

This definition of the first break-up date is significantly different from that in 1964 since the event to be recorded is the first stage in the final break-up of the season. Break-up (2) was renamed "water clear of ice" and given a similar definition to that previously operative as "... the earliest date on which the water was reported to be completely free of all floating ice, and remained so until the following freeze-up."

In addition to these changes, dates relating to trafficability were also tabulated. As is shown in Fig. 1, this generated categories of dates entitled "ice safe for traffic" in the freeze-up period, and "ice-unsafe for traffic" in the break-up period. Two other categories entitled "other date regarding freeze-up" and "other date regarding break-up" were included to accommodate dates of water navigability and dates of freeze-up and break-up described in vague terms which militated against their incorporation into the main break-up and freeze-up categories defined above.

4 Discussion

A scrutiny of these changes in definition indicates that they reflect a desire to reconcile two general groups of influences which can be characterized as historical and scientific respectively.

Prior to the 1950's there were no official efforts to standardize observations of break-up and freeze-up and these operations were conducted by a miscellany of private and public organizations. Consequently, a wide variety of definitions of break-up and freeze-up were operative at many of the early observation sites. It is clear that if the 1959 publication of dates had been restricted to a tabulation of dates which conformed to particular definitions, many of the interesting old records would have been ignored. For example, in the first tabulation of dates (Canada, Meteorological Branch, 1959) only 34 per cent of 217 stations observed break-up, and only 52 per cent of 195 stations observed freeze-up, strictly according to the official definitions in this publication. The earliest published definitions (Fig. 1) appear to have been strongly influenced by historical considerations of this nature. Subsequent changes of definitions reflect a desire to adapt these to scientific needs.

Purely scientific considerations appear to account for the following general changes in observational criteria in the period 1950-71: (1) dates should mainly refer to the final thaw period, and to the final freeze period; (2) dates should refer to the beginnings and ends of these periods, and (3) there should be observation of dates when ice commences and ceases to be trafficable.

Between 1957 and 1971 the published definitions were modified in a piecemeal manner to accommodate these criteria.

The modifications were generally preceded by earlier changes in instructions to observers contained in official circulars. In Fig. 1 changed or new definitions are enclosed in rectangles and, when these changes can be related to an earlier circular, this is identified in parentheses. These modifications are still in progress as witnessed by the fact that the current forms for reporting dates of break-up (Canada, Atmospheric Environment Service, 1972) and freeze-up (Canada, Atmospheric Environment Service, 1973) accommodate information on the trafficability of ice with respect to specified weights of vehicle. This innovation, which first appeared in 1969, has not yet been adopted as a new definition in the published dates.

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