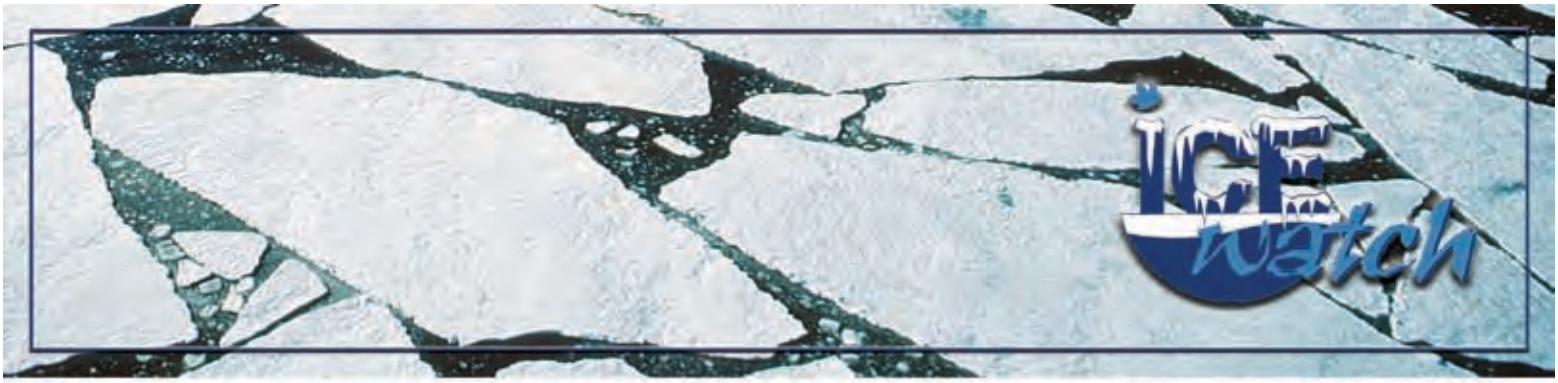


Changes in Lake Ice Signal a Changing Climate

IF YOU HAVE NOTICED the ice on your nearby pond or lake freezing later and thawing sooner than it used to, you are not alone. Scientists, for many decades, have been studying patterns of change in the dates in which water bodies' first freeze and thaw as an indicator of climate change. Tracking and analyzing these "ice-on" and "ice-off" events is known as ice phenology. Canadian ice phenology records show that freshwater ice is melting earlier than before.

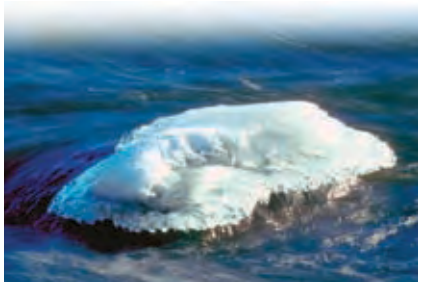
An old tradition is the new indicator

Many Canadians have been tracking ice freeze and thaw dates for decades, often just for interest, or even as part of a lottery. By looking at changes over time, this information can, in fact, be turned into a powerful indicator for tracking climate changes. Ice phenology is simple to track, at a very low cost without specialized training or equipment. Some records of "ice-on" and "ice-off" predate temperature records, giving an important glimpse into past climatic conditions. Scientists and researchers have relied on these voluntary records to extend their geographic reach and complement satellite and remotely sensed data.

Canadian ice enthusiasts are monitoring changes through IceWatch (www.icewatch.ca). Launched in 2001, IceWatch is a citizen-science program in which volunteer observers record the dates of ice formation and thaw on water bodies of interest to them following a standardized protocol. Any water body that usually freezes in winter can be monitored, particularly freshwater lakes and rivers, though

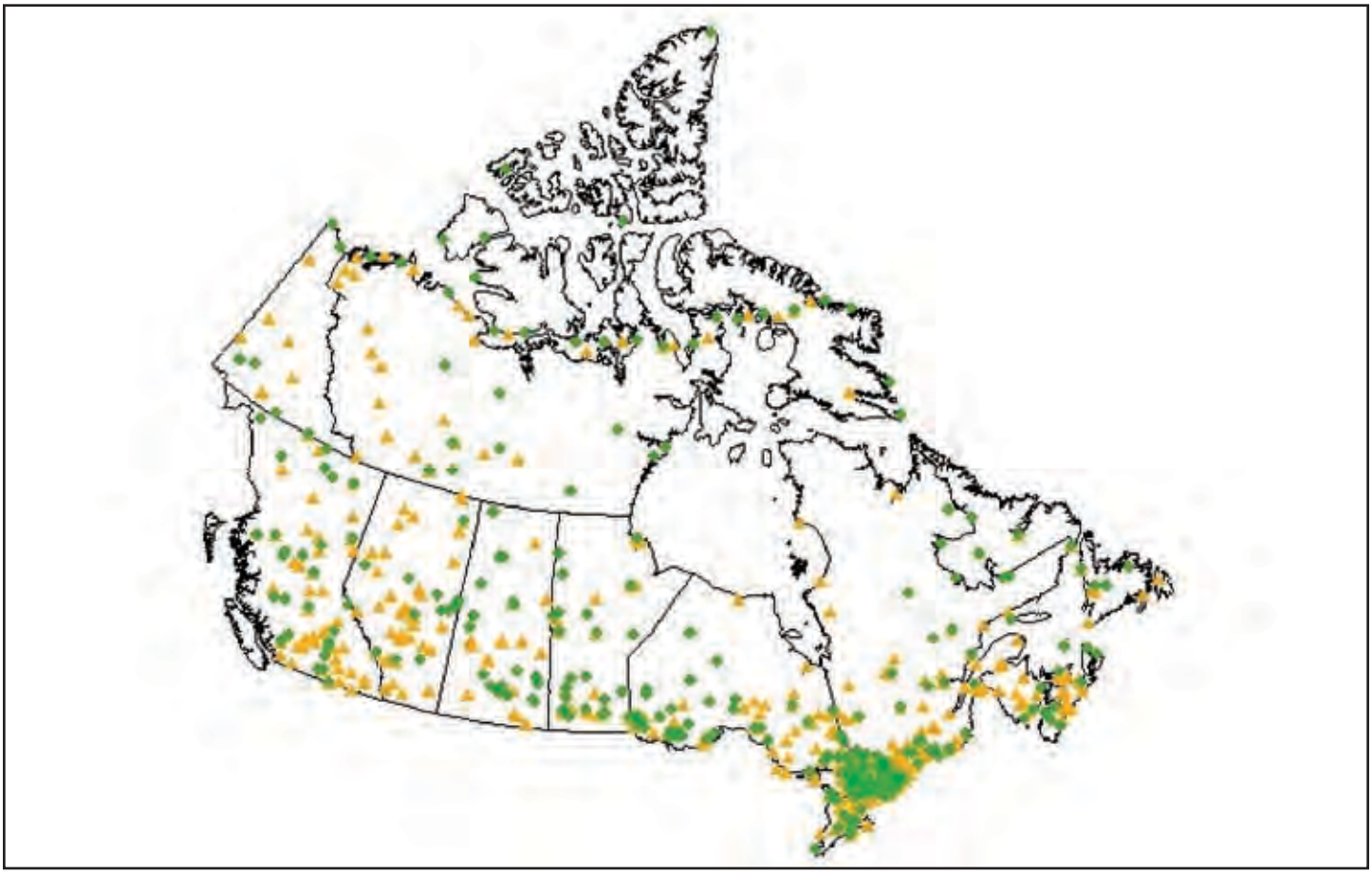
Dawson City Ice Pool

In 1896, prospectors in Dawson City, Yukon bet on the exact minute when ice break up would begin on the Yukon River. A bell attached to a cord tied to tripods on the river signaled the first shifting of the ice. The Ice Pool has become an annual tradition since that first winter. The bell has rung as early as April 9th and as late as May 28th. The bell has been replaced with a clock that registers the minute the ice goes out. For much of the twentieth century, ice was breaking up in May, but since the mid-1980s, most of the break up dates have occurred in April.



Map of ice observing sites

Sites marked with green dots were used in trend analysis. Sites identified by yellow triangles did not have a sufficiently long enough series of records for inclusion in trend analysis.



saltwater sites can also be used. Over 380 observers now participate.

This analysis combines data from IceWatch with data collected through historical ice monitoring programs managed by the Meteorological Service of Canada (MSC) and the Canadian Ice Service (CIS). The combined ice records date from as early as 1822 and as late as 2007. Together, the programs have collected data from approximately 950 sites across Canada. The longest series of records span 165 years, but most series are short: 303 sites have just one or two years of data.

What do the ice records tell us?

Ice records indicate that our climate is changing and that most sites are experiencing earlier thawing dates, signalling a warming trend in spring, particularly in western Canada.

Freshwater ice is melting earlier

Trends were calculated for each series of records having at least eight years of observations, the last of which was made in 1990 or later. Series ending prior to 1990 were not included in the analysis as they may not adequately reflect the recent observed pattern of climate warming. This analysis focused primarily on the break up date of lake ice as lake ice is the most sensitive to long-term climatic events.

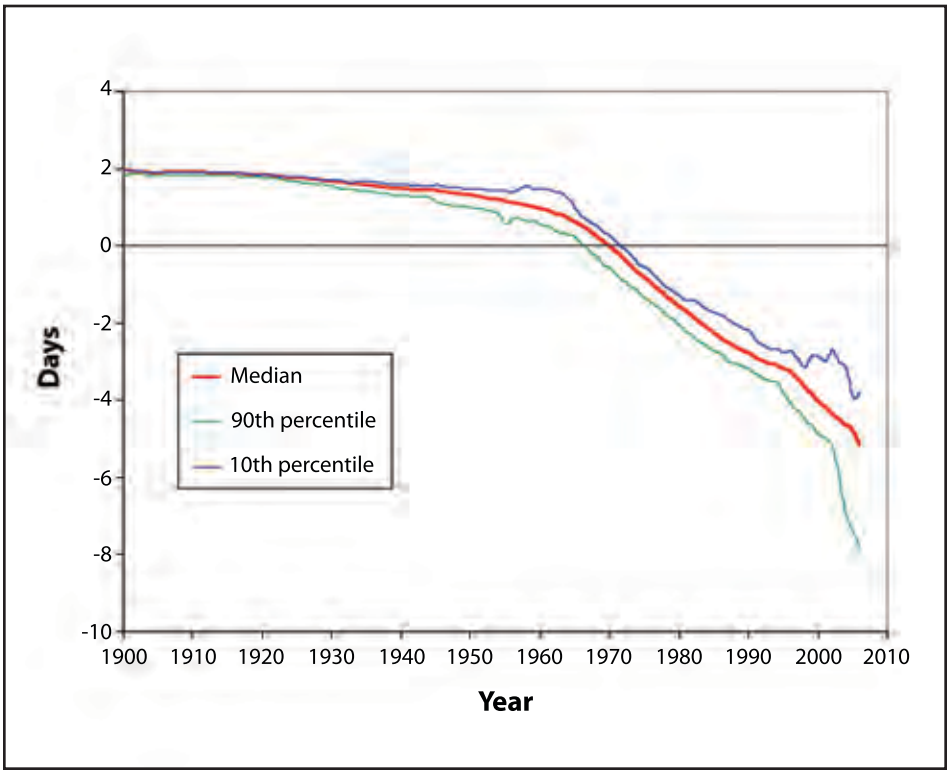
The analysis of ice-off data indicates a trend toward earlier spring thaw at freshwater sites across Canada. Forty of the 258 ice-off series had statistically significant trends towards earlier ice-off dates while five of the series had significantly later ice-off dates. In some lakes, the ice is not freezing at all. For example, no complete ice cover formed on

Trends analysis of ice phenology records

Ice-on	
Sites analyzed	195
Sites trending toward earlier freeze-up	73
Sites with significantly earlier freeze-up	15 (8%)
Sites trending toward later freeze-up	112
Sites with significantly later freeze-up	15 (8%)
Sites with no trend	10
Ice-off	
Sites analyzed	258
Sites trending toward earlier melt	168
Sites with significantly earlier melt	40 (16%)
Sites trending toward later melt	75
Sites with significantly later melt	5 (2%)
Sites with no trend	15

Change in lake ice thaw dates relative to a 1970 baseline

Values greater than 0 are indicative of later thaw while values less than 0 indicate earlier break up.



Michipicoten Bay near Wawa, Ontario in three of the seven most recent years of a 21-year record.

The change in dates on which lake ice thawed was plotted from 1900 to 2006. The graph reveals that there was relatively little change in thaw date between 1900 and 1950. There is a slight trend towards earlier ice thaw dates but the rate of change is slow; approximately 1 day earlier every 45 years. From 1950 to the present, however, the rate of change of ice thaw is much more rapid; approximately 1 day earlier every 7 years. In 2006, the date of ice thaw was 5 days earlier than it had been in 1970. There is greater variability in more recent estimates of rates of change for lake ice break up dates.

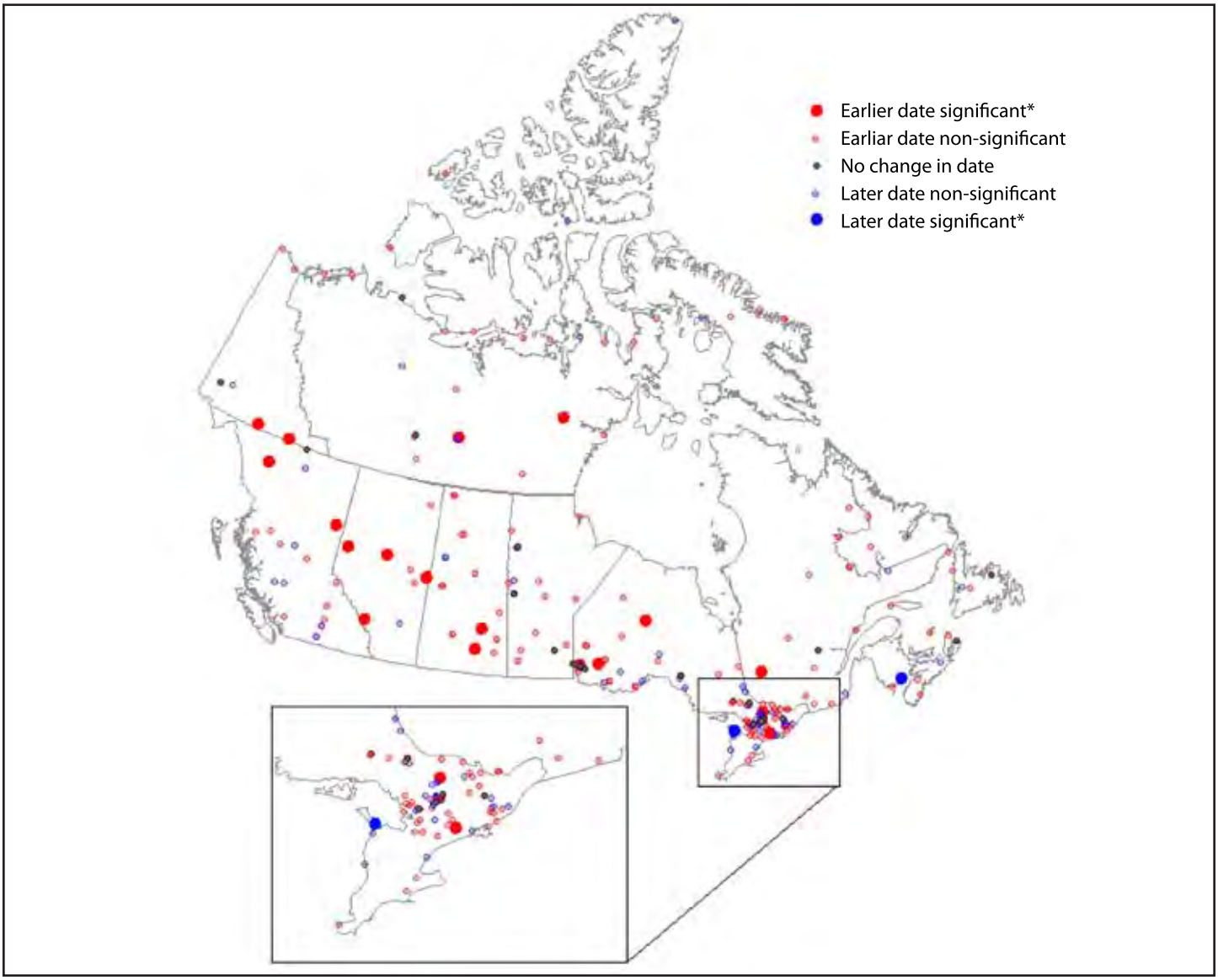
The warming trends are spatially distinct

A more detailed analysis of the ice-off data shows that most of the sites experiencing strong warming trends are concentrated in western Canada. Rate of thaw date change at significant sites ranged from two to four days per decade.

IceWatch data are meant to provide a first approximation of changes, extend the breadth of more rigorous studies and provide Canadians with an understanding of ecosystem changes in their own neighbourhoods. Though shorter time series associated with more recent ice records create wider range estimates and may show geographical variability, they are still very helpful in describing how the climate is changing. IceWatchers can help to reduce this variability by recording ice observations in the same way each year, tracking for many years, and training their successor. Even with such measures, there will be some inconsistency among the ice records as the effects of climate change will not be uniform.

Change in lake ice thaw date across Canada, 1950–2005

*Lake sites with significant trends at the 90% confidence level and measurements covering at least 60% of the 1950 to 2005 time span.



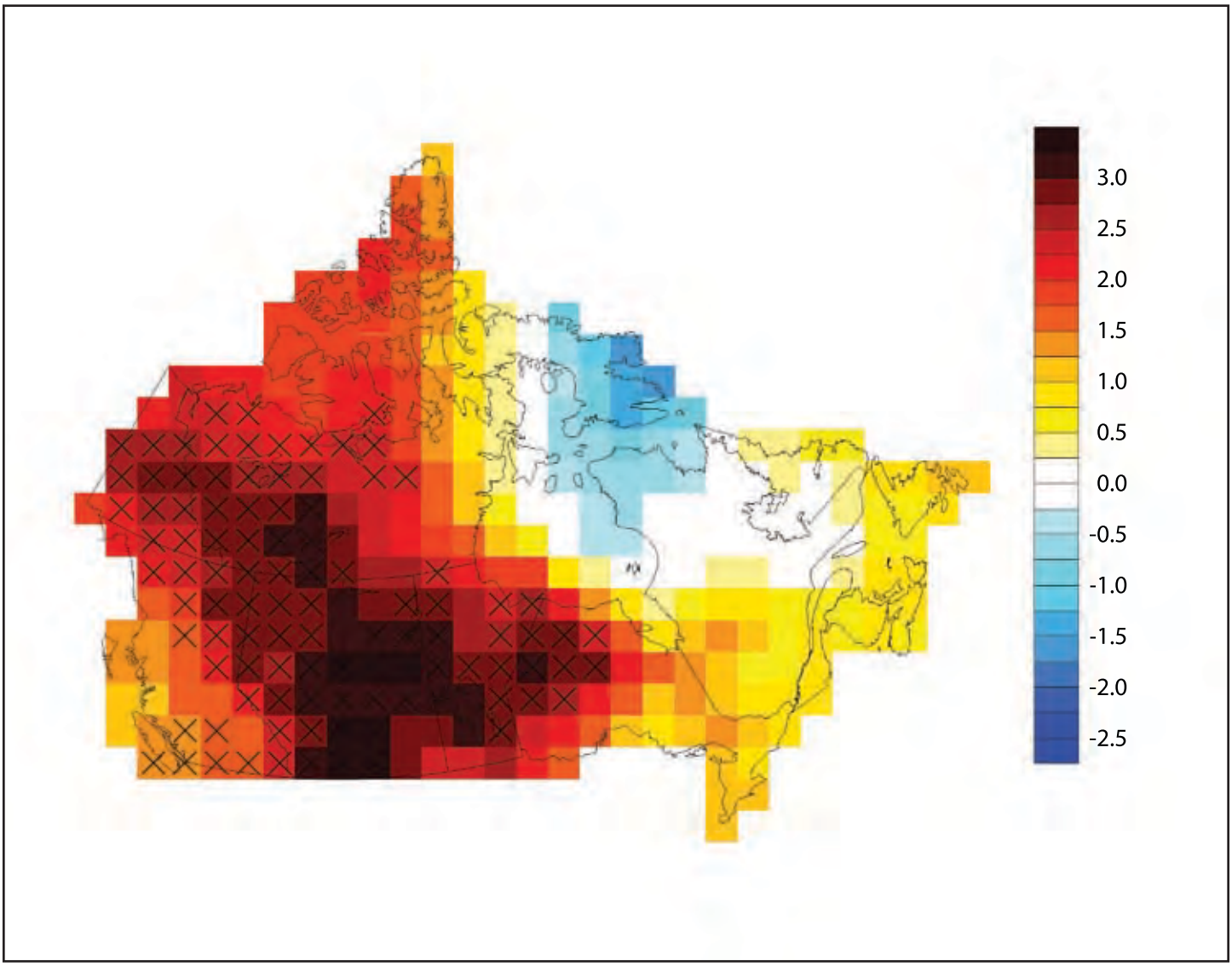
How do ice records compare with other climate data?

Professional and volunteer ice monitoring programs are observing similar patterns of climate change impacts. These trends have been documented in peer reviewed journal articles. Trends described in the ice records are similar to trends in the temperature and snow cover duration records. Analyses by Environment Canada scientists have shown that annual temperatures across Canada have risen by an average of 1°C since 1950, with the greatest warming trends occurring in the west and northwest.

The trend to earlier spring ice break up is consistent with earlier snow cover melt observed over much of southern Canada and particularly over western Canada.

Change in spring mean temperature for Canada, 1948–2003

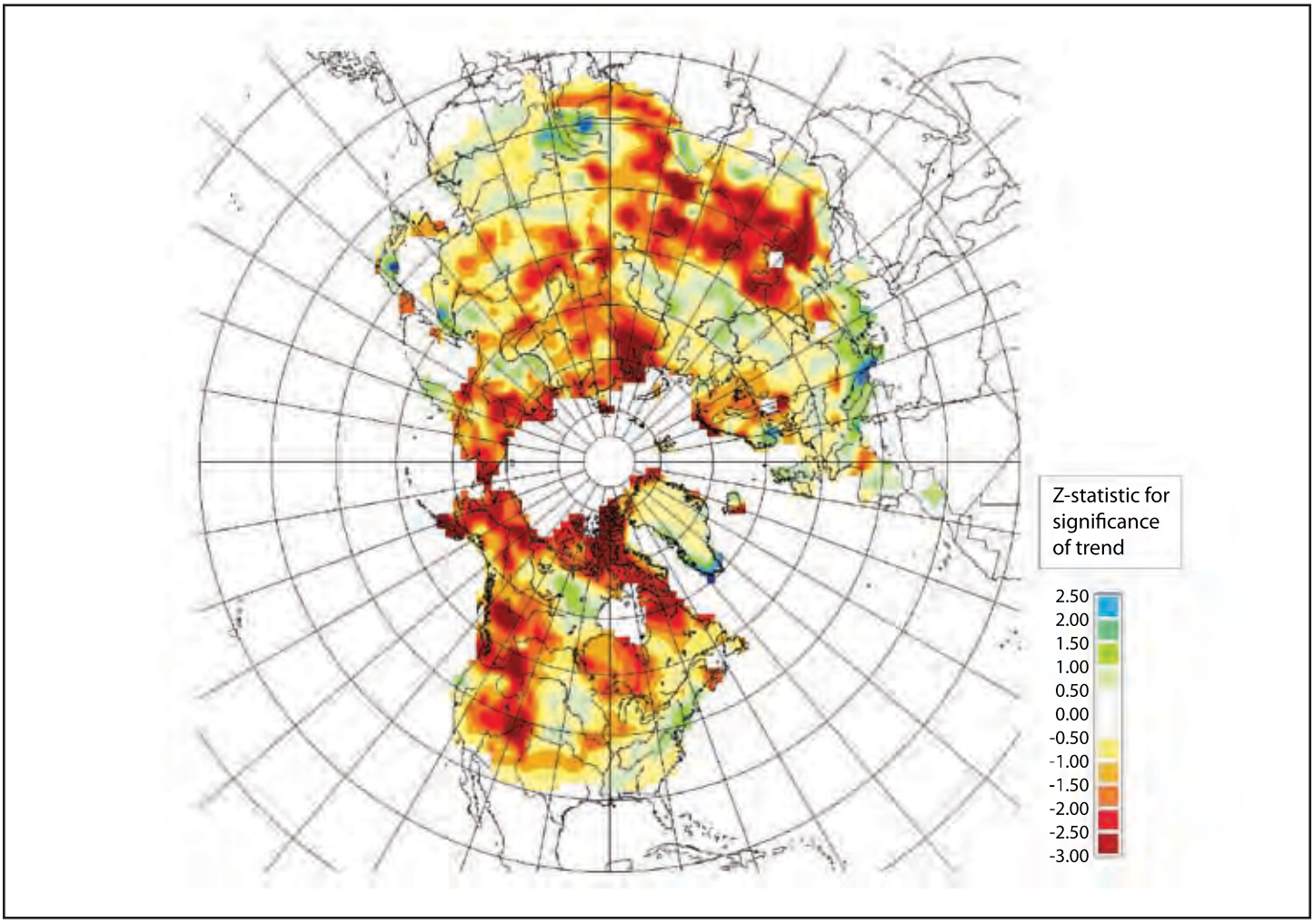
Courtesy of: Climate Research Division, Science and Technology Branch, Environment Canada. Units are ºC. Grid squares with trends statistically significant at 95% are marked by crosses.



Change in spring snow cover duration, 1966–2007

Orange-red tones indicate areas where spring snow cover (i.e. number of days with snow on the ground from January to July) is melting earlier. Values exceeding +/- 2 exhibit local changes that are statistically significant at the 95% level.

Results over high latitudes and mountain areas have higher uncertainty due to changes in mapping procedures and satellite data coverage over time. Based on National Oceanic and Atmospheric Administration's weekly snow cover dataset, courtesy of Dr. David Robinson, Rutgers University. Analysis and image courtesy of Ross Brown, Environment Canada.



What does this mean for Canadians?

Many Canadians, particularly in northern communities, rely on frozen lakes and rivers as a key transportation corridor. Shorter ice duration is already making northern travel and transport more difficult and expensive. Access to traditional hunting grounds for indigenous communities has been impaired. Winter recreational activities — including skiing, snowmobiling and ice fishing — will be affected over the long term. These activities, enjoyed by many Canadians, can be a major source of winter employment in many rural communities.

Timing of ice formation and thaw can also affect the ecology of lakes and rivers. Many wildlife species depend on consistency in the freeze and thaw events of bodies of water for food sources, hibernation, and migration.

The value of citizen science

These results demonstrate how volunteer monitoring information can complement data collected using instruments, such as temperature, as well as professional monitoring programs. Volunteer monitoring information can fill gaps in geographic coverage where sensor data and scientific surveys may not be available. As well, volunteers are the eyes and ears on the ground, ready to observe environmental phenomena as they occur. When following a standardized protocol and with proper training and tools, citizen scientists can make a great contribution toward our collective understanding of ecological status and trends.

What you can do

Only through the contribution of citizens can monitoring climate change impacts using ice phenology records continue. Everyone is welcome to participate in the IceWatch program. Log-on to www.icewatch.ca to familiarize yourself with the protocol then get outside and start monitoring! All observations, whether short- or long-term, provide essential information that can be used in analysis of climate records. Long-term ice data sets and records from areas where we have little geographic coverage are particularly valuable.

For more information visit www.icewatch.ca.

www.icewatch.ca

Published by Authority of the Minister of the Environment
© Her Majesty the Queen in Right of Canada, 2008
Catalogue No.: En84-65/2008E-PDF
ISBN 978-1-100-11308-1
Legal deposit – National Library of Canada, 2008
Aussi disponible en français sous le titre : *Les changements dans la glace des lacs annoncent des changements climatiques*