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VIEWPOINT - POINT DE VUE

Future prospects for backyard skating rinks look bleak in a warming climate

Robert McLeman[1] | Saeed Golian[2] | Conor Murphy[2] | Colin Robertson[1]

[1]Department of Geography and Environmental Studies, Wilfrid Laurier University, Waterloo, Canada

[2]Department of Geography/ICARUS, Maynooth University, Ireland

Correspondence to / Adresse de correspondance
Professor Robert McLeman, Wilfrid Laurier University, 75 University Ave West, Waterloo, ON N2L 3C5, Canada.
Email/Courriel: rmcleman@wlu.ca

Abstract

Each winter, purpose-built outdoor skating rinks are constructed in backyards and community parks across much of Canada and the northern United States. Past research projects that warmer winters will make it increasingly difficult to build outdoor rinks without artificial refrigeration. Here we build upon previous studies by mapping areas of North America where present average January temperatures are generally suitable each year for building outdoor rinks, and how this area will change by the 2050s and 2080s. Using projections from downscaled general circulation models, we show how under current emissions pathways, average January temperatures will become too mild by the 2050s to build outdoor rinks across much of eastern North America in most winters, and this area will expand by the 2080s to include most of the western United States. Under high emissions scenarios (RCP 8.5), unsuitably mild January temperatures expand to include densely populated areas of Canada's Prairie provinces by the 2080s. In short, many North Americans who build outdoor rinks every winter will, by mid-century, be living in areas where temperatures are only cold enough to do so occasionally, creating a range of social, cultural, and health implications for people living in those regions.

KEYWORDS
outdoor skating, outdoor rinks, hockey, climate change, citizen science

Résumé

Chaque hiver, des patinoires extérieures sont construites dans les arrière-cours et les parcs publics au Canada et dans le nord des États-Unis. Des recherches sur le climat laissent croire que d'éventuels hivers plus chauds rendront difficiles la construction de patinoires extérieures sans réfrigération artificielle. Nous nous appuyons ici sur ces études climatiques pour cartographier les régions d'Amérique du Nord où les températures moyennes actuelles de janvier conviennent généralement chaque année à la construction de patinoires extérieures. En utilisant les projections des modèles de circulation générale à échelle réduite, nous montrons comment, dans le cadre des trajectoires d'émissions polluantes actuelles, les températures moyennes de janvier deviendront trop douces, d'ici les années 2050, pour construire des patinoires extérieures

dans la majeure partie de l'est de l'Amérique du Nord. En outre, cette zone s'étendra d'ici les années 2080 pour inclure la majeure partie de l'ouest des États-Unis. Dans les scénarios d'émissions élevées (RCP 8.5), les températures inhabituelles en janvier s'étendent aux zones densément peuplées des provinces des Prairies du Canada d'ici les années 2080. En bref, de nombreux Nord-Américains qui construisent des patinoires extérieures chaque hiver vivront, d'ici le milieu du siècle dans des régions où les températures ne le permettent plus, ce qui aura des conséquences diverses sur les habitants de ces territoires.

MOTS CLÉS
patinage, patinoires extérieures, hockey, changement climatique, science citoyenne

Key messages

- By the 2050s, average January temperatures across much of eastern North America will be too mild to construct and maintain outdoor skating rinks in most winters.
- Under high emissions scenarios, by the 2080s January temperatures will become too mild for annual construction of outdoor skating rinks in almost all of the lower 48 US states and much of the Canadian prairies.
- Outdoor skating provides many significant social, cultural, and health benefits that will be lost as purpose-built rinks become increasingly rare.

Outdoor skating is a popular winter pastime across much of Canada and the northern United States (US) that takes place opportunistically on the frozen surfaces of lakes and ponds and on purposefully constructed rinks in public spaces and in the yards of private homes. Will this activity continue to be possible in a rapidly changing climate and, if so, where? These questions made North American headlines in March 2023 with the surprising announcement that the world's largest outdoor skating rink—Ottawa's Rideau Canal Skateway—would for the first time in its history not open because prolonged mild temperatures combined with rainfall and heavy snow had prevented the formation of ice strong enough to support maintenance equipment (Austen, 2023). The average number of skating days per winter on the Canal has been declining since the 1970s (Agrawal & Jahanandish, 2019; Brammer et al., 2014; Jones et al., 2006), but the inability to open at all nonetheless came as a shock to local residents and the Skateway's managers, with popular media reports attributing it to climate change (e.g., Vardon, 2023).

Despite being a popular subject of past studies examining the future of outdoor skating, the Rideau Canal is an imprecise indicator of the effects of climate change on outdoor rinks given its unique hydrological and operational characteristics: it is neither a purpose-built rink nor a natural waterway, and at least 30 cm of solid ice must form before it opens for skating, because it must support the weight of vehicles used for maintenance and snow removal. Indeed, although the Skateway never opened, backyard rinks in the Ottawa area were operational well into late March 2023. This is because purpose-built backyard skating rinks have very different characteristics than ice formed on the Canal, and on natural waterways more generally, and they can offer opportunities for skating when ice on lakes and ponds (and canals) is unsafe. Also, they can be built in locations where no natural water bodies are present or nearby. For these reasons, purpose-built rinks collectively provide more potential days for skating in a typical winter than do other options, and will increasingly become the place where most outdoor skating takes place in a more variable and warming climate.

Thousands of outdoor skating rinks are built each winter in private yards and public spaces across much of Canada and the northern US (Figure 1) using one of two methods. The simplest and least expensive method is to wait until an area of level ground has frozen and then apply on successive nights thin layers of water using a hose from a standpipe until a continuous, smooth, and hard ice surface is built up (a process referred to as "flooding"). An alternative approach is to enclose an area with wooden boards, attach within them a plastic liner, and then commence flooding. The latter method allows for a skateable surface to be built more quickly and, should warm temperatures temporarily melt the rink's surface, the water does not drain away, allowing for a quicker re-freezing of the skating surface once cold weather returns. However, liners are expensive, are easily damaged by skates, and limit the size of the rink. For these reasons, outdoor rinks built in public spaces tend to be constructed in the simpler fashion, making them more susceptible to damage from midwinter thaws.

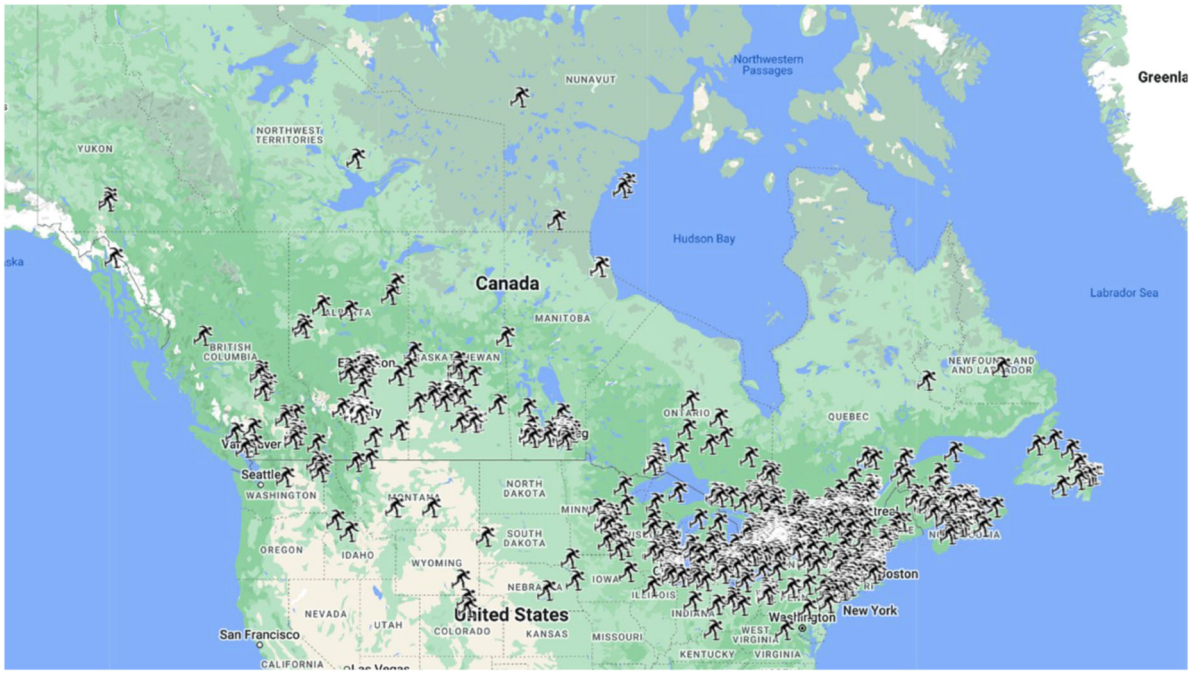

FIGURE 1 Map showing location of outdoor skating rinks that have participated in RinkWatch citizen science project since 2013.

In addition to the type of construction, site-specific factors such as slope, aspect, and exposure to sunlight affect the number of skating days on a given rink, as does the experience and skill of the rink maker. Meteorological factors such as the quantity, timing, and type of precipitation also have an influence; for example, freezing rain early in the winter can supplement the flooding of the rink but can damage the surface if it falls later in the winter. Heavy midwinter snow can delay skating until it is removed, or act as an insulating layer that prevents complete freezing of a soft ice surface underneath. Whilst these and other factors collectively serve to reduce the number of skating days, the overarching determinant of the ability to build and maintain an outdoor skating rink is ambient air temperature.

Using data submitted by amateur rink makers through the citizen science project RinkWatch (www.rinkwatch.org), Robertson et al. (2015) published in this journal probability curves that estimate the likelihood of rinks in ten Canadian cities being skateable at given air temperatures. Although the curves vary by several tenths of a degree Celsius from one location to another, reflecting variations in non-temperature factors, these probability curves show that when average daily temperatures are colder than −5°C, the majority of established rinks in most locations will be skateable, with the probability approaching 100% as average daily temperatures reach −10°C.

The effects of historical trends in winter temperatures on outdoor skating rinks have been the subject of two peer-reviewed studies to our knowledge. In the first of these, Damyanov et al. (2012) used a −5°C temperature threshold to estimate historical changes in outdoor skating conditions in Canada. The authors found that across most of Canada the start date of the outdoor skating season has been falling later in the year as compared with the 1950s, and that in southern Ontario and southern Quebec the overall number of days suitable for outdoor skating days per winter has declined. The authors compared their results with observed variations in the North Atlantic Oscillation and the Pacific North American teleconnection pattern and found the association to be statistically significant beyond 99%. In a later study, Malik et al. (2020) reviewed daily winter temperature records since the 1940s for the "Original Six" National Hockey League (NHL) cities of Boston, Chicago, Detroit, Montreal, New York City, and Toronto. Each of the six cities displayed a decreasing number of especially cold days per winter (i.e., colder than −5.5°C) that are ideally suited for outdoor skating rinks, with Toronto exhibiting the most notable decline.

The potential impact of future temperature change on purpose-built rinks has been studied for three locations in Canada, all showing a likely decline in the ability to build rinks. In the aforementioned Robertson et al. (2015) study, the authors calculated $p = .5$ temperature thresholds for the cities of Calgary, Toronto, and Montreal, then used decadal weather projections from Intergovernmental Panel on Climate Change (IPCC) A2 emissions scenarios (the standard of the day) to conclude that, by the 2090s, the number of days suitably cold enough for skating on a backyard rink would shrink by 34% for Toronto and Montreal and by 19% for Calgary. A separate study for the city of Montreal conducted by Dickau et al. (2020) projected that the length of the city's outdoor skating season by the end of this century could range from 41 days per winter under low-emission Representative Concentration Pathway (RCP) 2.6 scenarios to only 11 days under RCP 8.5 scenarios, the latter period being so short it is unlikely anyone would bother attempting to construct a rink. The future of outdoor skating in the Adirondack region of New York state was the focus of a study by Rosales et al. (2021), who were interested in the implications of warming temperatures on the availability of outdoor ice for the development of young hockey players. Using methods similar to those of the aforementioned studies, they found the Adirondack region

would experience significant loss of skating opportunities under high emissions scenarios, but minimal loss if emissions reduction commitments under the Paris Agreement were to be realized.

To obtain a wider picture of the future implications of warming temperatures on rinks across North America as a whole, we mapped those areas where average January temperatures are currently suitable for purposefully building and maintaining an outdoor skating rink, and then mapped how this geographical area would change in response to future temperature changes projected under standardized greenhouse gas (GHG) emissions scenarios. Unlike previous studies that have sought to estimate the total number of skating days for specific locations under a range of climate scenarios, here we assess changes over time on average temperatures for the coldest winter month, rather than temperature changes across the entire winter season, and focus on the implications of only the most realistic and plausible GHG emissions scenarios for the 2050s and 2080s. In areas that do not routinely experience sufficiently cold temperatures in January, few people expect to be able to create purpose-built ice rinks on a regular yearly basis, though they may do so opportunistically during anomalously cold periods in a given winter. In areas where people do regularly construct rinks, if the ice is not skateable in January due to unseasonably mild temperatures, the rink is often abandoned for the remainder of the season—as was the case for much of eastern North America in January 2023 according to www.rinkwatch.org data. Both actual and expected temperatures in early or late winter months appear to have much less influence on the propensity to construct rinks, as suggested by the wide regional variations in first and last dates of skating recorded in annual RinkWatch project reports. Consequently, the most straightforward way to identify where North Americans are likely to construct outdoor skating rinks on a regular basis in future decades is to map changes in the location of the −5°C isotherm of average mean daily temperatures for the month of January.

We extracted the necessary data to do this from three dynamically downscaled Global Climate Models (GCMs) that comprise the North American Regional Climate Downscaling Experiment (NA-CORDEX) (Mearns et al., 2017): the CCCma-CanESM2 + CRCM5 GCM/RCM models and MPI-M-MPI-ESM-LR + CRCM5 models produced by Université du Québec à Montréal (UQAM) and the EC-EARTH + HIRHAM5 GCM/RCM model produced by the Danish Meteorological Institute. The NA-CORDEX ensemble is driven by ERA-Interim historical reanalysis and by a suite of GCMs forced using different RCPs. We used runs available at 0.44°/50 km spatial resolution and employed the bias-corrected version of each GCM-driven data set, adjusted against gridded daily observations by using a multivariate quantile-mapping method developed by Cannon (2018). From these data we computed the mean daily temperature for January for each grid cell for the recent historical period of 1981–2000 and for the 2050s (2041–2060) and 2080s (2071–2090) and mapped the outcomes under RCP 4.5 for both periods and under RCP 8.5 for the 2080s.

Figures 2–5 show the results of our analyses, with Figure 2 identifying those areas that have until recently had January temperatures well suited for building outdoor skating rinks. Of the four RCPs, RCP 4.5 provides the most realistic (and a mildly optimistic) warming scenario for the 2050s, as its estimates of cumulative mid-century emissions are slightly lower than what can be expected given current global emissions trends and GHG emission reduction commitments made to date under the UN Framework Convention on Climate Change (Schwalm et al., 2020). While there is some variability across the three GCMs in identification of the southernmost border of the January −5°C isotherm, under RCP 4.5 virtually all of the eastern US and the most densely populated areas of southern Ontario and southern Quebec will, by the 2050s, fall south of the climatic area with January temperatures that are routinely suitable for building outdoor skating rinks (Figure 3). Under RCP 4.5, the −5°C isotherm continues to move northward into the 2080s, excluding most of the lower 48 US states (Figure 4). Residents of the western Canadian prairie provinces will then find themselves on the southernmost frontier of the suitable climatic area, with inter- and intra-annual temperature variability having a much greater impact on the ability to build and maintain a rink than at present. Under RCP 8.5, which can be seen as a worst-case scenario for outdoor skating, the −5°C isotherm shifts so far north in the second half of this century that locations where winters without outdoor skating rinks are unheard of at present, such as Edmonton and Saskatoon, would fall south of the suitable climatic area in some models (Figure 5). A plausible best-case scenario for outdoor rinks for the 2080s is one where countries act rapidly in the next 10 to 20 years to make substantial reductions in GHG emissions—a scenario that seems very remote given that global emissions are rising steadily at the moment—in which case, the −5°C isotherm is unlikely to retreat much farther north than is shown in Figure 3.

Because these maps are based on average temperature trends, locations that fall out of the climatically suitable range will still occasionally experience winters (or multi-week periods within them) so much colder than average that rinks may be built opportunistically, as is currently done by outdoor skating enthusiasts in locations like Philadelphia and Vancouver. Given the nature of their construction, public rinks that are built by flooding directly onto frozen ground are likely to be the first casualties of the geographical shift in the January −5°C isotherm. Warming temperatures will similarly reduce the number of winter days that ice on natural water bodies is suitable for recreational activities including skating (Fairley et al., 2015; Woolway et al., 2022). The net effect of these trends is that the number of public spaces where North Americans can skate outdoors will observably decline with each passing decade, with the best remaining opportunities being in private yards where rinks are constructed using plastic liners.

This begs the question of why we should care. Compared with the many severe ecological and economic impacts of climate change expected to emerge (Intergovernmental Panel on Climate Change, 2022), losing the ability to build an outdoor skating rink in Montreal, Chicago, or (eventually) Edmonton may seem trivial, particularly to those who do not live in places with cold climates or who are not skating enthusiasts. However, outdoor skating has been documented as providing a wide range of social, cultural, and health benefits, both tangible and intangible, to households and communities (Fredericksen et al., 2018). Many cold-weather municipalities in North America provide residents with public

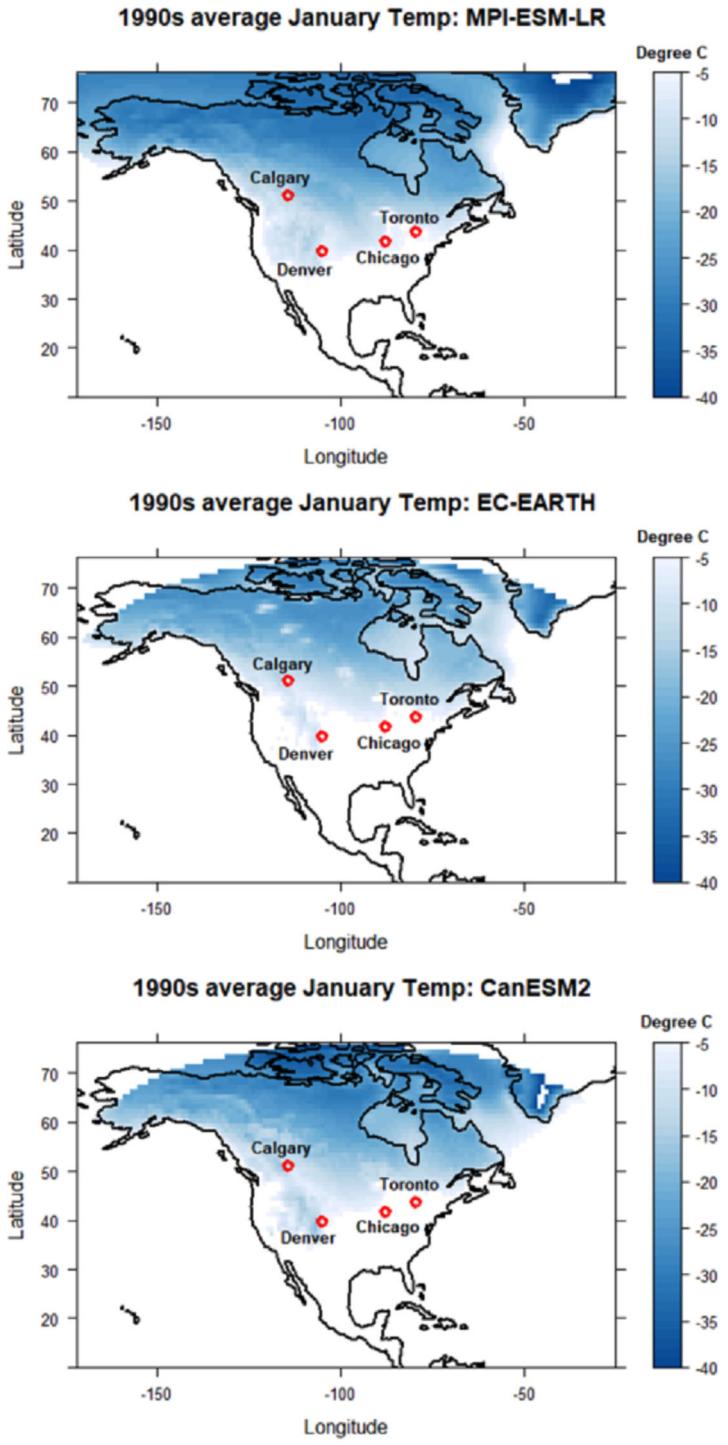

FIGURE 2 Areas in the 1990s with average January daily temperatures colder than −5°C. Selected cities where outdoor skating rinks are currently found are labeled to provide reference points for readers (only cells colder than −5°C are displayed for ease of viewing).

outdoor skating rinks as an option for winter recreation, facilities that have relatively modest financial costs—the Rideau Canal Skateway being an exception, costing nearly $1 million annually to operate (Pritchard, 2023). As winter temperatures warm, these municipalities will need to choose between ceasing to provide outdoor skating facilities altogether or adapting by switching to artificially refrigerated outdoor rinks. The latter approach is far more expensive and may be beyond the financial means of some municipalities, and requires the use of energy to run compressor equipment and refrigerants that may be GHG, thereby making the outdoor rink itself a potential contributor to global warming.

Apart from refrigerated artificial outdoor rinks, there are other alternatives that will become increasingly important as access to naturally formed outdoor ice diminishes, such as indoor ice arenas and a variety of synthetic plastic surfaces that give the sensation of skating on ice. However, what

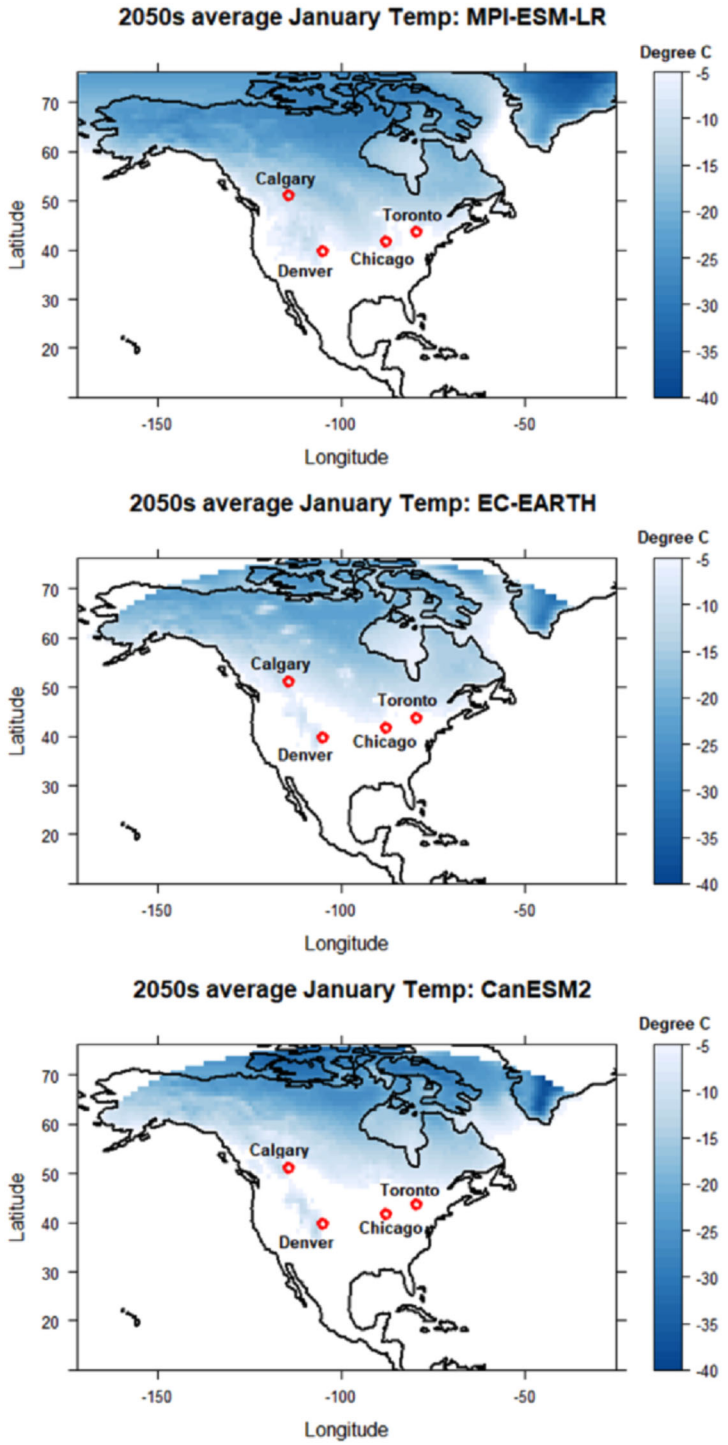

FIGURE 3 Areas in the 2050s with average January daily temperatures colder than −5°C in RCP 4.5 scenarios.

will be lost is the democratizing effect of frozen ponds and natural outdoor ice rinks: anyone with a pair of skates can participate. Even outdoor rinks built in private backyards are done so with a view to sharing the space with friends and neighbours (Fredericksen et al., 2018). By comparison, indoor ice facilities are fewer and less accessible, and they are often monopolized by organized hockey and figure skating activities whose joining costs are often beyond what many families can afford. The NHL has expressed growing concern about the sustainability of outdoor skating, for ponds and backyard rinks have been the entry point for the sport for generations of children, some of whom one day become professionals but many more of whom become potential lifelong fans (see the NHL Green website https://www.nhl.com/info/nhl-green). Amateur hockey federations in Canada and the US have emphasized the importance of outdoor rinks as a place for young athletes to sharpen skills in ways not possible on indoor ice, and to acquire enough playing time to master the sport (Rosales et al., 2021). Concerns about the future viability of outdoor winter sports in a changing

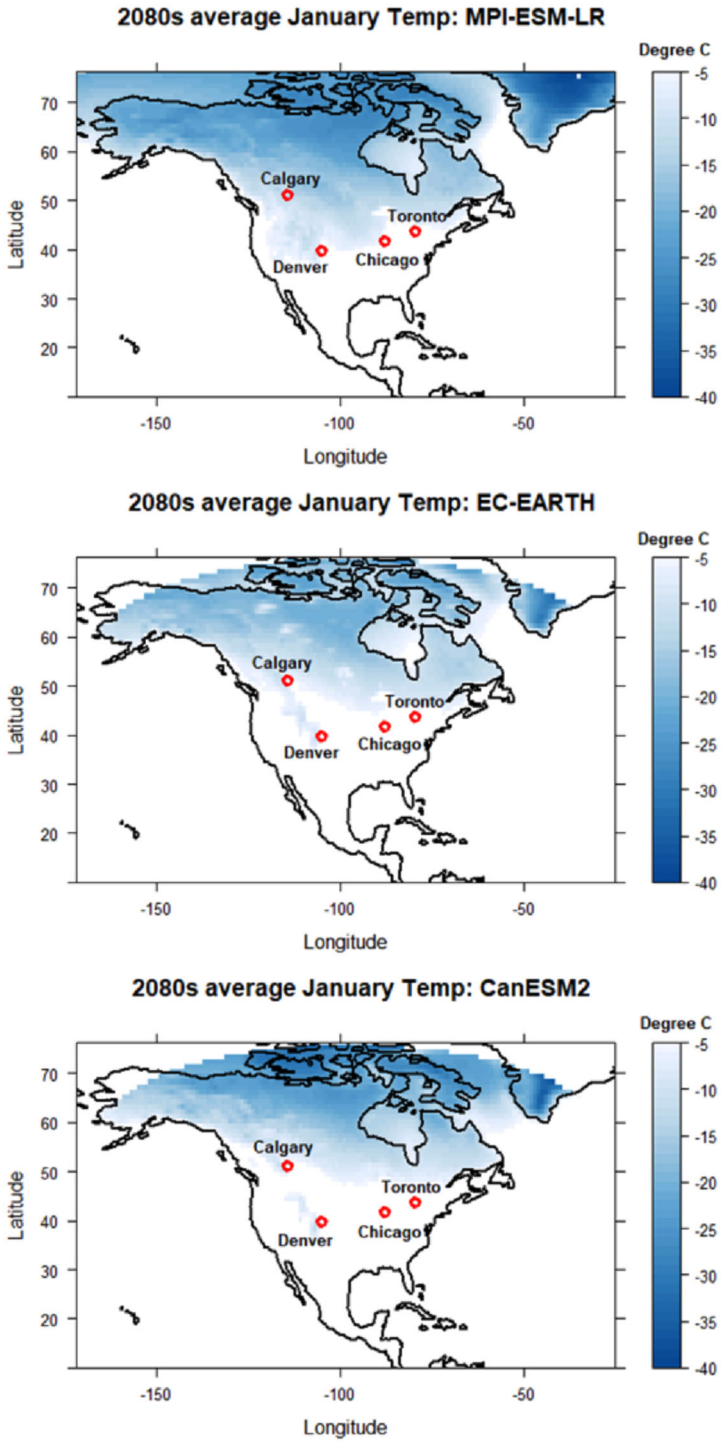

FIGURE 4 Areas in the 2080s with average January daily temperatures colder than −5°C in RCP 4.5 scenarios.

climate have also been raised by skiing, sledding, and other sporting federations, with "Save our Winters" being the theme of the 2023 FISU World Student Winter Games in Lake Placid. Citizen science initiatives such as RinkWatch.org and SavePondHockey.org are also trying to raise awareness. It remains to be seen if concerted action on the part of these groups and by other entities in the larger world of organized sports, where sustainability is a growing concern, will help catalyze public demands for GHG emission reductions, upon which the future of outdoor skating depends.

As things presently stand, the future for outdoor skating looks bleak. For many North American children born today, the ability to skate outdoors will within their lifetime become only an occasional treat. But rather than despair, we encourage readers to see it as an opportunity for researchers and winter sports enthusiasts to work together in communicating to the public the risks of failing to reduce GHG emissions.

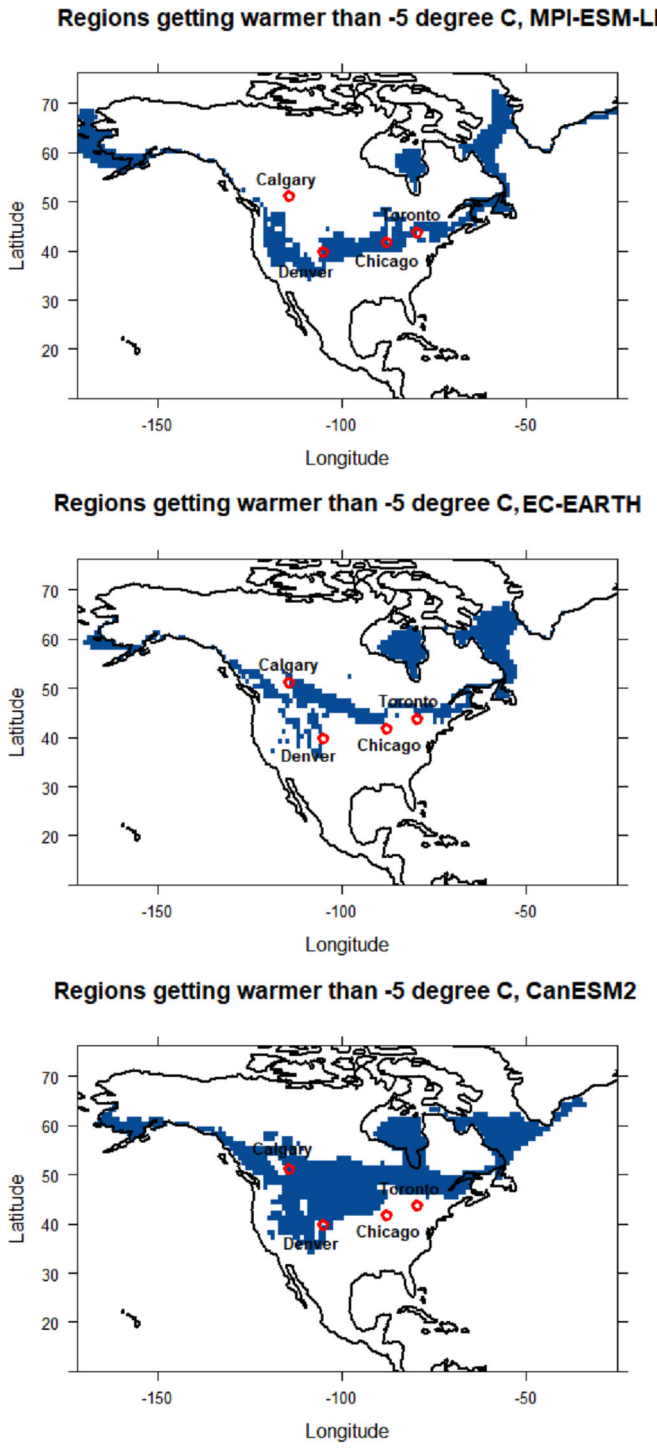

FIGURE 5 Areas that disappear from the −5°C isotherm region by the 2080s in RCP 8.5 scenarios.

The disappearance of outdoor skating opportunities is something many North Americans can observe happening literally in their own backyards and local parks—in contrast to other examples of the impacts of warming winter temperatures with which people may already be familiar, such as shrinking polar ice caps and disappearing glaciers, but that are more remote from everyday experience. Hopefully, the loss of outdoor skating and all the traditions and cultural benefits that accompany it are one cost of climate change people will be unwilling to accept.

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ORCID

Robert McLeman http://orcid.org/0000-0001-9593-1606

REFERENCES

Agrawal, N., & Jahanandish, A. (2019). Is climate change impacting Rideau Canal Skateway, the world's longest skating rink? *Natural Hazards*, *98*(1), 91–101. https://doi.org/10.1007/s11069-018-3459-9

Austen, I. (2023, 25 February). For the first time in 52 years, there's no skating through the capital. *New York Times*. https://www.nytimes.com/2023/02/25/world/canada/rideau-canal-skateway-ottawa.html?partner=IFTTT

Brammer, J. R., Samson, J., & Humphries, M. M. (2014). Declining availability of outdoor skating in Canada. *Nature Climate Change*, *5*(1), 2–4. https://doi.org/10.1038/nclimate2465

Cannon, A. J. (2018). Multivariate quantile mapping bias correction: An N-dimensional probability density function transform for climate model simulations of multiple variables. *Climate Dynamics*, *50*(1), 31–49. https://doi.org/10.1007/s00382-017-3580-6

Damyanov, N. N., Matthews, H. D., & Mysak, L. A. (2012). Observed decreases in the Canadian outdoor skating season due to recent winter warming. *Environmental Research Letters*, *7*, 014028. https://doi.org/10.1088/1748-9326/7/1/014028

Dickau, M., Matthews, D., Guertin, É., & Seto, D. (2020). Projections of declining outdoor skating availability in Montreal due to global warming. *Environmental Research Communications*, *2*, L51001. https://doi.org/10.1088/2515-7620/ab8ca8

Fairley, S., Ruhanen, L., & Lovegrove, H. (2015). On frozen ponds: The impact of climate change on hosting pond hockey tournaments. *Sports Management Review*, *18*(4), 618–626. https://doi.org/10.1016/j.smr.2015.03.001

Fredericksen, A., McLeman, R., & Elcombe, T. (2018). Building backyard ice rinks in Canada: An exploratory study. *Leisure/Loisirs 42*(1), 47–68. https://doi.org/10.1080/14927713.2017.1411822

Intergovernmental Panel on Climate Change (2022). *Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, UK and New York, NY, USA. https://doi.org/10.1017/9781009325844.001

Jones, B., Scott, D., & Khaled, H. A. (2006). Implications of climate change for outdoor event planning: A case study of three special events in Canada's National Capital Region. *Event Management*, *10*(1), 63–76. https://doi.org/10.3727/152599506779364615

Malik, K., McLeman, R., Robertson, C., & Lawrence, H. (2020). Reconstruction of past backyard skating seasons in the Original Six NHL cities from citizen science data. *The Canadian Geographer / Le Géographe canadien*, *64*(4), 564–575. https://doi.org/10.1111/cag.12640

Mearns, L., McGinnis, S., Korytina, D., Arritt, R., Biner, S., Bukovsky, M., Chang, H-I., Christensen, O., Herzmann, D., Jiao, Y., Kharin, S., Lazare, M., Nikulin, G., Qian, M., Scinocca, J., Winger, K., Castro, C., Frigon, A., & Gutowski, W. (2017). The NA-CORDEX dataset, version 1.0. NCAR Climate Data Gateway, Boulder, CO. https://doi.org/10.5065/D6SJ1JCH

Pritchard, T. (2023, 6 April). NCC has spent nearly $1M trying to open Skateway this winter. *CBC News*. https://www.cbc.ca/news/canada/ottawa/ncc-rideau-canal-skateway-2023-costs-not-opening-1.6802314

Robertson, C., McLeman, R., & Lawrence, H. (2015). Winters too warm to skate? Citizen-science reported variability in availability of outdoor skating in Canada. *The Canadian Geographer / Le Géographe canadien 59*(4), 383–390. https://doi.org/10.1111/cag.12225

Rosales, J., Pettengill, P., Van Duersen, J., Quinn, J., & Dufour, J. (2021). The impact of climate change on hockey expertise in the North Country and Adirondack Region of New York. *Adirondack Journal of Environmental Studies*, *24*(1) 7–17. https://digitalworks.union.edu/ajes/vol24/iss1/2

Schwalm, C. R., Glendon, S., & Duffy, P. B. (2020). RCP8.5 tracks cumulative CO2 emissions. *Proceedings of the National Academy of Sciences*, *117*(33), 19656–19657. https://doi.org/10.1073/pnas.2007117117

Vardon, S. (2023, 8 March). Mourners say climate change killed the Rideau Canal skating season in 2023. *CTV News*. https://ottawa.ctvnews.ca/mourners-say-climate-change-killed-the-rideau-canal-skating-season-in-2023-1.6303896

Woolway, R. I., Huang, L., Sharma, S., Lee, S.-S., Rodgers, K. B., & Timmermann, A. (2022). Lake ice will be less safe for recreation and transportation under future warming. *Earth's Future*, *10*(10), e2022EF002907. https://doi.org/10.1029/2022EF002907

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