A SURVEY OF CLIMATE INFORMATION NEEDS AMONG USERS IN ONTARIO, CANADA

Ontario Centre for Climate Impacts and Adaptation Resources (OCCIAR) is a university-based resource hub for researchers and stakeholders and provides information on climate change impacts and adaptation. The Centre communicates the latest research on climate change impacts and adaptation, liaises with partners across Canada to encourage adaptation to climate change and aids in the development and application of tools to assist with municipal adaptation. The Centre is also a hub for climate change impacts and adaptation activities, events and resources.
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SURVEY RESULTS SUMMARY

The following represent a summary of the key messages taken from the survey of users of climate data in Ontario:

- ✓ The top three hazards that most survey respondents seek to manage for are extreme rainfall events, long-term precipitation changes, and long-term temperature changes.

- ✓ For many climate variables, the preferred reporting interval for weather/climate data is daily, especially for temperature and precipitation data. Precipitation is the only climate variable that ranked highly in terms of a need for hourly interval data.

- ✓ The climate change impact that respondents are most concerned with is flooding. Knowledge of the precipitation regime including the frequency of precipitation events in the context of climate change is considered to be extremely important to the work of the survey respondents.

- ✓ Respondents noted the need for continued improvements to the spatial resolution of climate data while also recognizing the need for clear statements about levels of uncertainty and limitations in the data. This is in contrast to the reported level of knowledge on data uncertainty. The preferred spatial resolution for climate model output was municipal/community level (1 km^2 - 4 km^2), followed by regional level (5 km^2 - 100 km^2), which was considered a 'best match' to the scale of decision-making or work requirements.

- ✓ Model resolution at the regional, provincial or national scale does not offer the degree of certainty or relevance that many decision-makers wanted to see before making adaptation or other decisions.

- ✓ The A2 greenhouse gas emission scenario is the most *used* in the context of decision-making, along with the use of global models. There is much less uptake on using the new Representative Concentration Pathways (RCPs) compared to SRES scenarios, but both are equally preferred. Output from multiple models (ensembles) and downscaled/dynamically downscaled climate model outputs is most *preferred*.

- ✓ Environment Canada is most frequently consulted for historical climate data and climate projections, while most of the respondents access climate projections through publicly available, open websites.

- ✓ There is a preference for web-based material accompanying climate model data and information products to help improve the level of understanding of the uncertainty associated with climate model output.

- ✓ The top three applications of climate change projections are: a) to develop adaptation plans; b) to support research on future conditions; and c) to identify vulnerable regions, species and populations.

- ✓ Some of the most useful climate information products include analysis of extremes, maps of future changes and values, historical trends, analysis of IDF curves, and time series.

- ✓ There were repeated mentions of the importance of incorporating updated climate information into codes and standards that govern various aspects of infrastructure and community planning and development.

- ✓ There were calls for consistency in the reporting of climate information, specifically standardized baseline periods and length of reporting periods.

1.0 Introduction

Continued changes to climate and weather are driving increased attention to the identification and management of climate risks at local and regional levels. Adapting to the impacts of climate change is often the outcome of a spatially-specific and theme-sensitive planning processes that aims to identify vulnerabilities and risks, and identify actions to address those risks.

Fundamental to the climate decision-making process is climate data; comprised of both historic trends and future projections of select climate variables. Climate information paints the picture of how facets of temperature and precipitation have changed in the past and how they are expected to change into the future. Increased specificity of the data is helpful to further delineate spatial and temporal trends, and to appreciate changes to bioclimatic factors that are theme- or sector-specific (e.g. growing degree days for agriculture).

Specific climate data requirements drive a process whereby raw data is translated into information products that inform a variety of decisions for both natural and built systems. The pervasive nature of climate change and the depth of its impacts necessitate a variety of information products. A variety of agencies monitor and report climate data and many produce, and make available, information products for use by decision-makers and the general public. Use of these products in the decision-making context varies according to the end user's knowledge of the influence (sensitivity, exposure) of climate on the system and the capacity to obtain and use the products appropriately. The level of application of climate information products is not consistent across sectors or themes, nor is it consistent within or across regions.

In 2014, a survey was developed by the Ontario Centre for Climate Impacts and Adaptation Resources (OCCIAR) to gather details on the use of climate data in Ontario. Specifically, the survey sought to identify the needs (type) for climate information in Ontario, where decision-makers go to obtain climate data, and how that information is used in various decision-making contexts. Supported by Environment Canada, results from the survey are intended to inform ongoing enhancements to the development of climate information products and the delivery of climate services in Ontario and Canada.

1.1 Survey Methodology

The survey was comprised of 33 questions and was divided into 9 broad themes that captured information about the users, the user's application of data, and their current and future needs (see Appendix for a list of survey themes and questions). The survey was developed using Survey Monkey and was posted for a total of 63 days, running from December 2, 2014 to February 3, 2015.

The survey was distributed to OCCIAR's primary network (N=168) and to Ontario members of OCCIAR's National Climate Change Adaptation Community of Practice (N=386). The survey was further distributed to other networks including 1) those who attended the Ontario Ministry of

Environment and Climate Change Best in Science Symposium (December 2014; N=180); and 2) those who attended the Environmental Commissioner of Ontario's Climate Data Roundtable (January 2015; N≈70).

In total, there were 114 respondents to the survey, 80 of which completed the survey; resulting in a 70% completion rate. The response rate was 14% however it is difficult to provide an accurate rating since many of the people who were asked to complete the survey are members of more than one of the networks listed above.

2.0 Survey Results

2.1 Types of Respondents

This section provides information on the types of respondents who completed the survey, including the type of organization they are affiliated with, the sector they work in, the number of years they have been applying climate information to their decision making, and how important climate models are to their work.

Results indicate respondents from various types or organizations, across a number of different sectors, mainly water and sustainability. Climate model outputs are important to the work of the respondents, and over half of the respondents had more than 3 years experience working with climate models.

- Table 1 suggests that most of the respondents were either from an academic institution or working for a municipal or provincial government.
- There were also a number of respondents from Conservation Authorities and NGO's, with very little representation from industry.
- Table 2 shows that most of the survey respondents work within the water and sustainability sectors.
- The natural resource sectors with the highest percentage of survey respondents were forestry and energy.
- At the time of the survey,

Table 1 | Survey respondents by organization

	No. of Respondents	% of Total
Academic	15	19%
Government – Municipal	15	19%
Government – Provincial	12	15%
Conservation Authority	11	14%
Not-For-Profit	9	11%
Government – Federal	8	10%
Private Sector Consultant	7	9%
Industry	2	3%

Table 2 | Survey respondents by sector

	No. of Respondents	% of Total
Water	37	49%
Sustainability	34	45%
Planning	24	32%
Forestry	23	30%
Energy	22	29%
Education	21	28%
Health	18	24%
Agriculture	17	22%
Emergency Management	14	18%
Transportation	10	13%
Tourism	4	5%
Mining	3	4%
Financial	3	4%
Manufacturing	2	3%

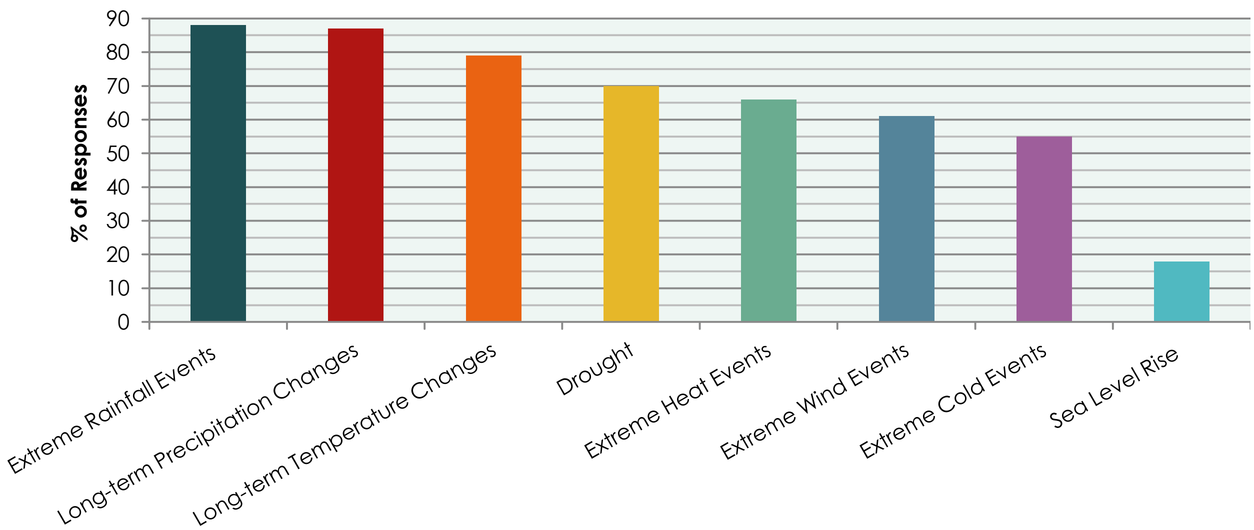
most of the respondents (41%) had over 5 years experience applying climate model outputs to their decision making, while 20% had 3-5 years experience, 16% had 1-2 years experience, 9% had less than one year of experience, and 14% had no experience.

- When asked to rate the importance of climate models to their work, 86% of respondents stated it was extremely important, very important, or important. Only one respondent from the survey considered climate models unimportant in their decision making, while 9% of respondents considered them neither important nor unimportant.

2.2 Climate Hazards and Impacts

This section identifies which facets of climate change the respondents seek to manage for in their particular line of work, as well as the climate change impacts that they are most concerned with. Although most of the climate change hazards ranked highly in terms of priority, the results show that the top two hazards that the survey respondents seek to manage are focused on precipitation (i.e. extreme rainfall events and long-term precipitation changes). Flooding is the number one climate change impact that respondents are most concerned about.

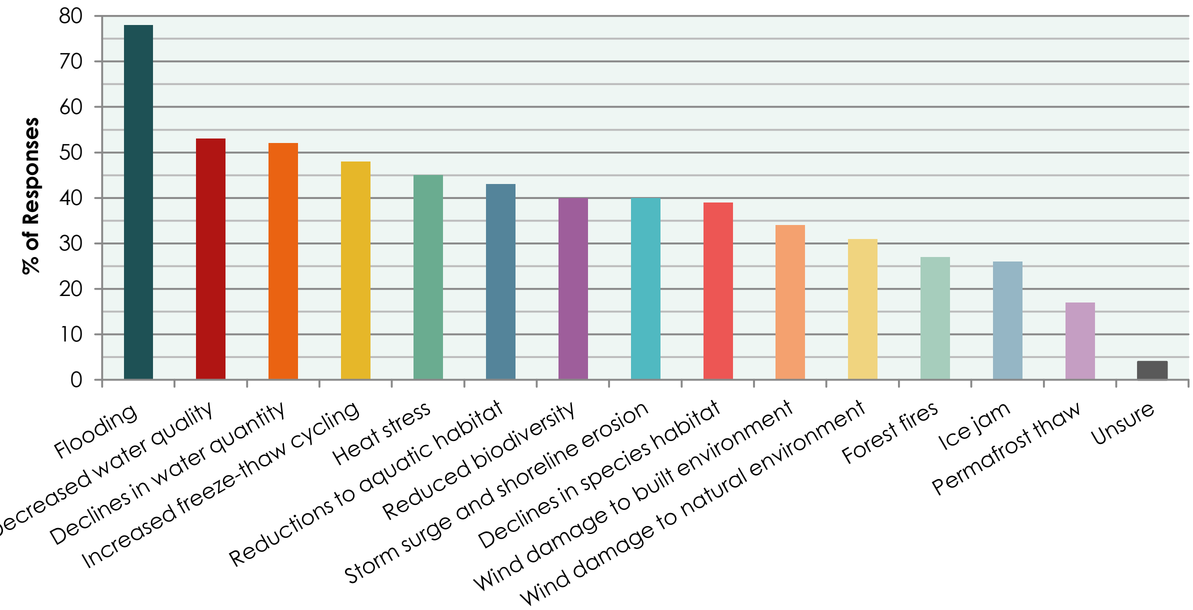
FIGURE 1 | Climate change hazards that respondents seek to manage



- The top three hazards that most end-users seek to manage are extreme rainfall events, long-term precipitation changes, and long-term temperature changes; but since respondents had the option of selecting more than one hazard, the majority of the hazards listed ranked fairly highly in terms of priority (see Figure 1).

- As to be expected in Ontario, very few users seek to manage sea level rise; however, 14 respondents identified sea level rise as a climate change hazard they are considering within their organization.
- One respondent from identified the need for climate data on mixed precipitation events, such as any combination of freezing rain, snow, rain, and ice pellets.

FIGURE 2 | Climate change impacts that respondents are concerned about



- Flooding was clearly the climate change impact that respondents are most concerned with (see Figure 2).
- Some respondents from the private sector identified each climate change impact as a concern, as they work with clients in various sectors and locations that can be affected by any number of climate change impacts.
- Additional climate change impacts were noted:
    - Insect outbreaks
    - Invasive species
    - Impacts to cultural landscapes
    - Impacts to crop growth and yield
    - Impacts on tree growth
    - Impacts to infrastructure (i.e. snow loading, flooding)
    - Climate refugees
    - Changes in vector habitat and migration (e.g. Lyme Disease, West Nile Virus), reduced air quality, reduced food security arising from extreme weather of any kind, damage to built environments of any kind (e.g. flooding, wind, heat-related) that could affect human health.

2.3 Climate Variables

This section ranks the importance of various climate variables. Once again, the survey results demonstrate that the respondents consider precipitation to be the most important climate variable to consider, including the frequency of precipitation events.

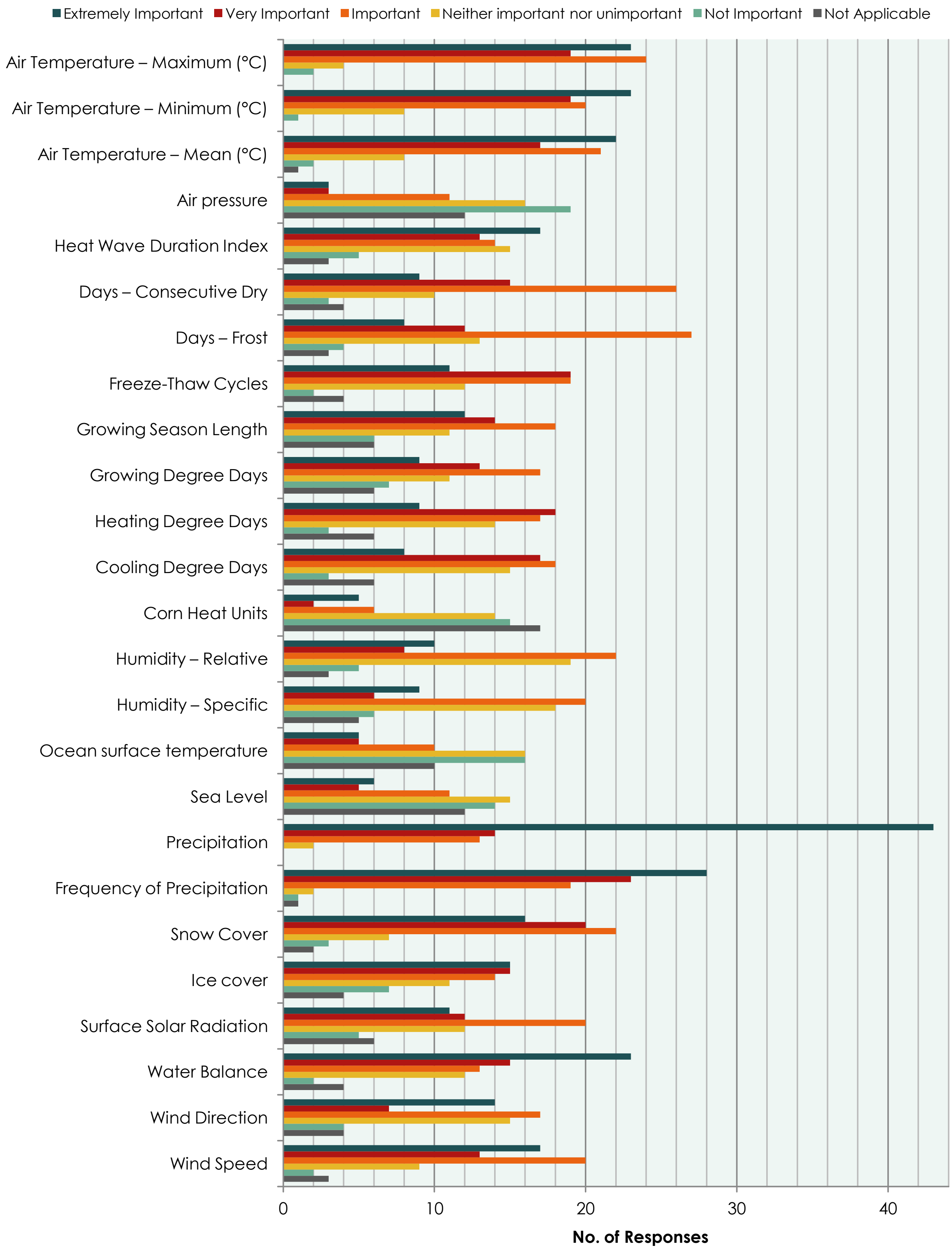
- Precipitation was "extremely important" to the work of the survey respondents, followed closely by the frequency of precipitation events (see Figure 3).
- Climate variables identified as "important" were consecutive dry days, frost days, snow cover, relative humidity, surface solar radiation, and wind speed.
- All three climate variables associated with air temperature (maximum, minimum, mean) were on the higher (more important) end of the response scale.
- Additional climate variables considered to be important were as follows:
    - Extreme weather events (i.e. extreme rainfall amounts and frequency)
    - Freezing rain events
    - Snow storm events
    - Soil moisture, water table (groundwater data)
    - Mean surface water temperature (inland lakes)
- Likely due to fewer respondents with expertise in these areas, climate variables that ranked lower in importance included:
    - Air pressure
    - Corn heat units
    - Ocean surface temperature
    - Sea level
- A survey respondent from the private sector explained that the importance of each climate variable depends on the type of client that they are working with, as they work with clients in various sectors and locations that are concerned about different climate variables.

2.4 Climate Model Resolution

This section discusses results that reveal preferred climate model spatial resolution for application in work settings as well as the most useful spatial resolution. Respondents also identified why particular resolutions are necessary, and limitations of other resolutions. Respondents prefer finer spatial resolution (1 km^2 - 4 km^2), but identified regional level spatial resolution (5 km^2 - 100 km^2) as a useful scale for climate model output. Only having regional level data was seen as an impediment to effective planning for climate change at the local level.

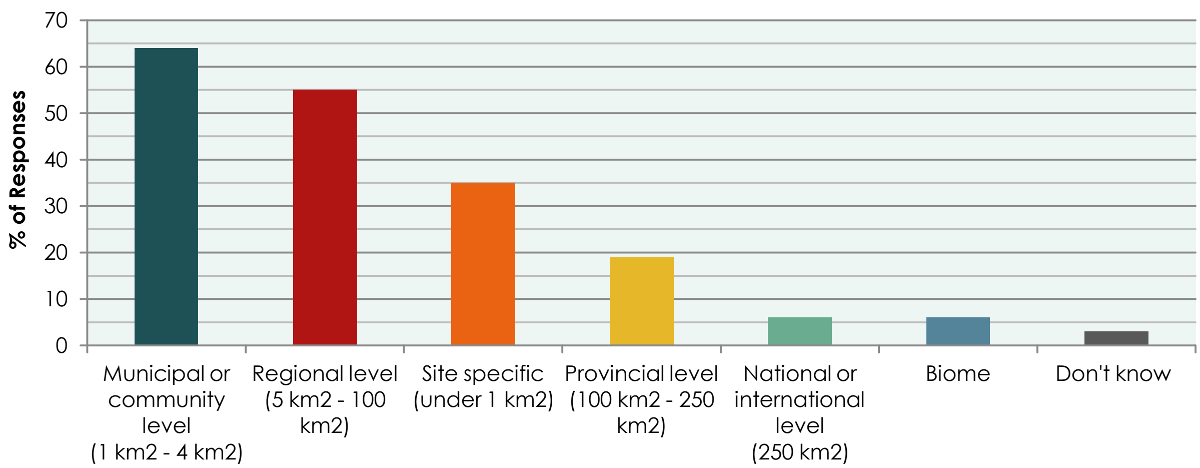
- The preferred climate model spatial resolution was the municipal/community level (see Figure 4). When asked why they felt this resolution is necessary, the following was mentioned:
    - Appropriate match to their decision-making context.

FIGURE 3 | Climate variables ranked by importance



- Some of the respondents prefer to use multiple spatial resolutions in order to take into account effects from regional to local, and to provide for 'scaled' mitigation and adaptation strategies.
- The survey respondents who identified municipal/community as their preferred climate model resolution explained that:
  - Regions are affected by weather patterns differently, therefore a smaller resolution is needed in order to see how different areas will be affected by a changing climate.
  - Municipal/community climate model resolution can help pinpoint local vulnerabilities and is the appropriate scale one should use when conducting risk and vulnerability assessments.
  - The municipal/community level is the scale where decisions are made around policy and actions on climate change within communities. Climate data at this resolution would be more relevant to municipal leaders and decision-makers, and would help convince municipal councilors that adaptation actions being taken are addressing the specific climate changes a community is likely to experience.

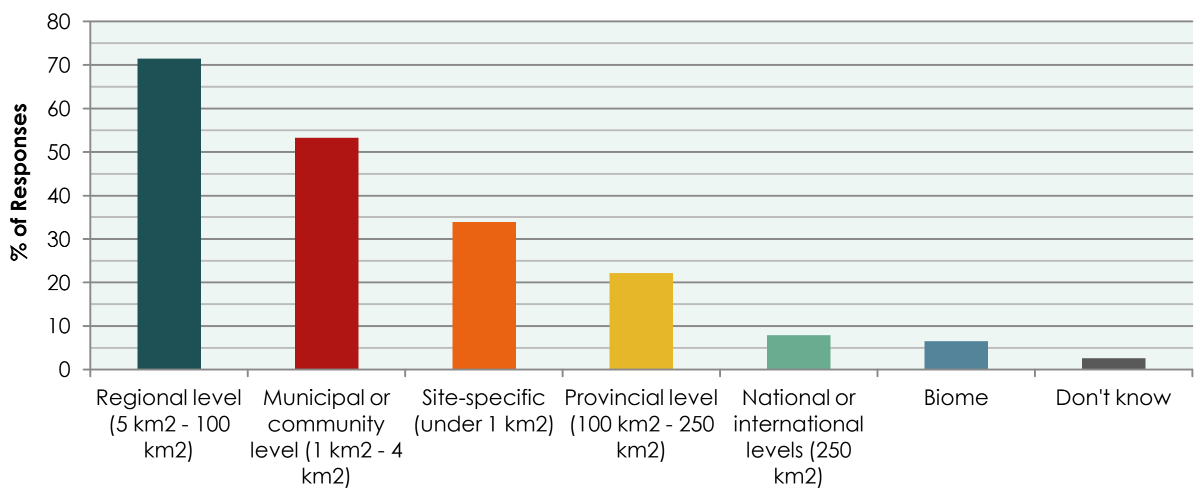
FIGURE 4 | Preferred climate model spatial resolution



- Figure 5 (below) suggests that the climate model spatial resolution deemed ***most useful*** was the regional level, followed by the municipal/community level.
- When asked what they would be <u>unable to accomplish</u> if they only had ONE resolution available to them, results indicated that:
  - Nuances related to different elevations and impacts of local water bodies would not be captured with only regional spatial resolution, potentially leading to some inaccuracy. Ultimately, this could reduce the level of confidence in the results.
  - Having only regional spatial resolution would impact the ability to plan specifically for local communities. For example, there would be less accuracy in identifying local sensitivities to events such as heavy/prolonged rainfall, as outputs become less relevant to local users as scale increases.

- A few respondents identified that there are other ways of affecting change that do not require accurate climate data, therefore only having climate data at the regional scale would be sufficient in many situations.
- If provincial scale resolution was the only resolution available, one respondent listed a few limitations, including: comparability to site-specific observations, representation of small scale climate processes, representation of small watersheds, inclusion of small lakes, and oversimplification of areas with complex terrain.
- Regional, provincial or national model resolutions do not offer the degree of certainty or relevance that many municipal leaders want to see before making decisions with large financial implications. One respondent mentioned that they would be unable to make a strong case for the municipality to adopt proactive measures to prepare for climate change impacts.

FIGURE 5 | Useful climate model spatial resolution



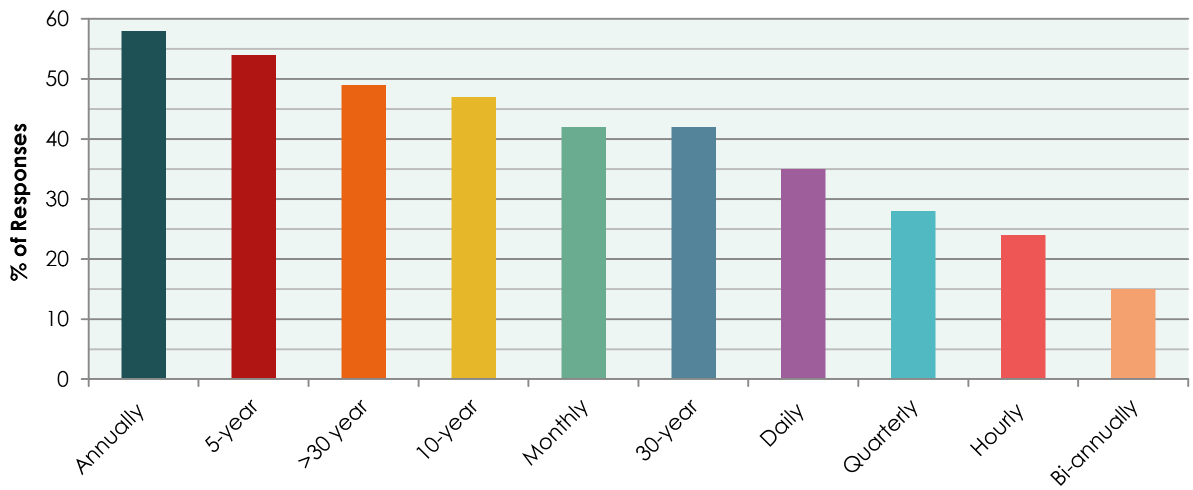
2.5 Timeframes and Time Intervals

Questions pertaining to timeframes and times queried the work planning timeframes, and preferences for weather/climate data time intervals. Most of the respondents plan on an annual or 5-year basis, however, that is mostly dependant on the purpose of the planning strategy. The preferred weather/climate data time interval for many of the climate variables (notably temperature and precipitation) was daily. Precipitation was the only climate variable that ranked highly in terms of hourly time interval needs.

- Figure 6 (below) highlights the largest number of respondents in the 1-year and 5-year planning categories, with only slightly lower numbers planning for 30-year and beyond 30-year time frames.

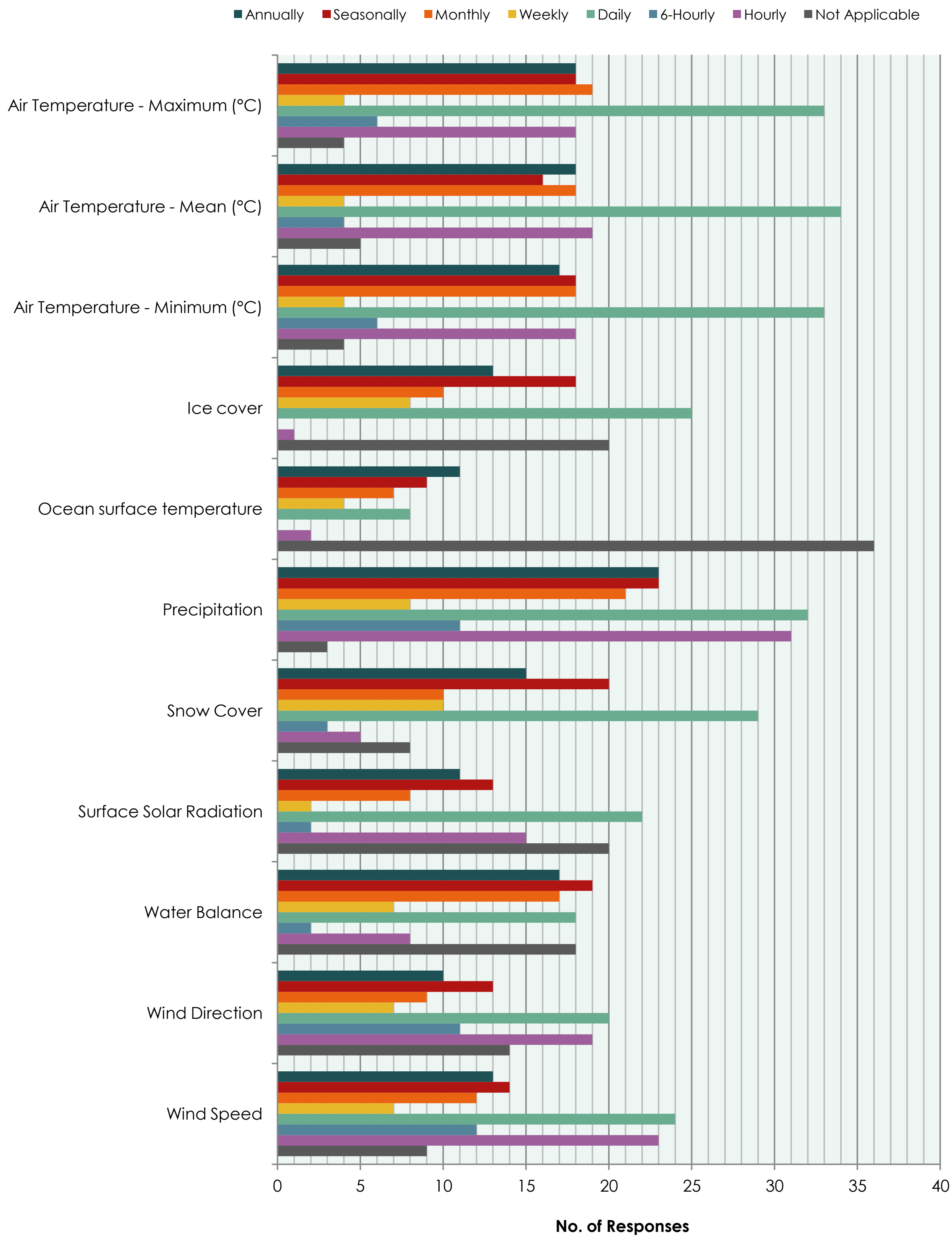
- A few respondents identified the need for data at various time intervals. For example, Conservation Authorities look at ongoing flood and drought risk which can be hourly/days/weeks/months, and also look at long-term planning considerations over 100 years.
- One respondent suggested that hourly and daily timeframes are critical for modeling aspects of hydrology. Otherwise, a monthly or greater timeframe is sufficient. Most research, however, looks at impacts within a 30-year time period.

FIGURE 6 | Timeframes respondents plan for



- Figure 7 (below) identifies the preferred weather/climate data time intervals for survey respondent's line of work. For most of the categories of climate variables, daily was the preferred time interval.
- Requests for hourly precipitation and wind speed were noted.
- As a climate variable, precipitation ranked highly in all of the time intervals, except for weekly and 6-hourly.
- Maximum, minimum and mean air temperature ranked highest in terms of daily time intervals, but also annually, seasonally, monthly and hourly.
- The weather/climate variable that was considered the least desirable to the survey respondents was ocean surface temperature. Ice cover, surface solar radiation and water balance were also not as desirable as some of the other climate variables.
- An additional climate variable was identified by the survey respondents: lake surface temperatures (especially from large inland lakes).

FIGURE 7 | Preferred weather/climate time intervals

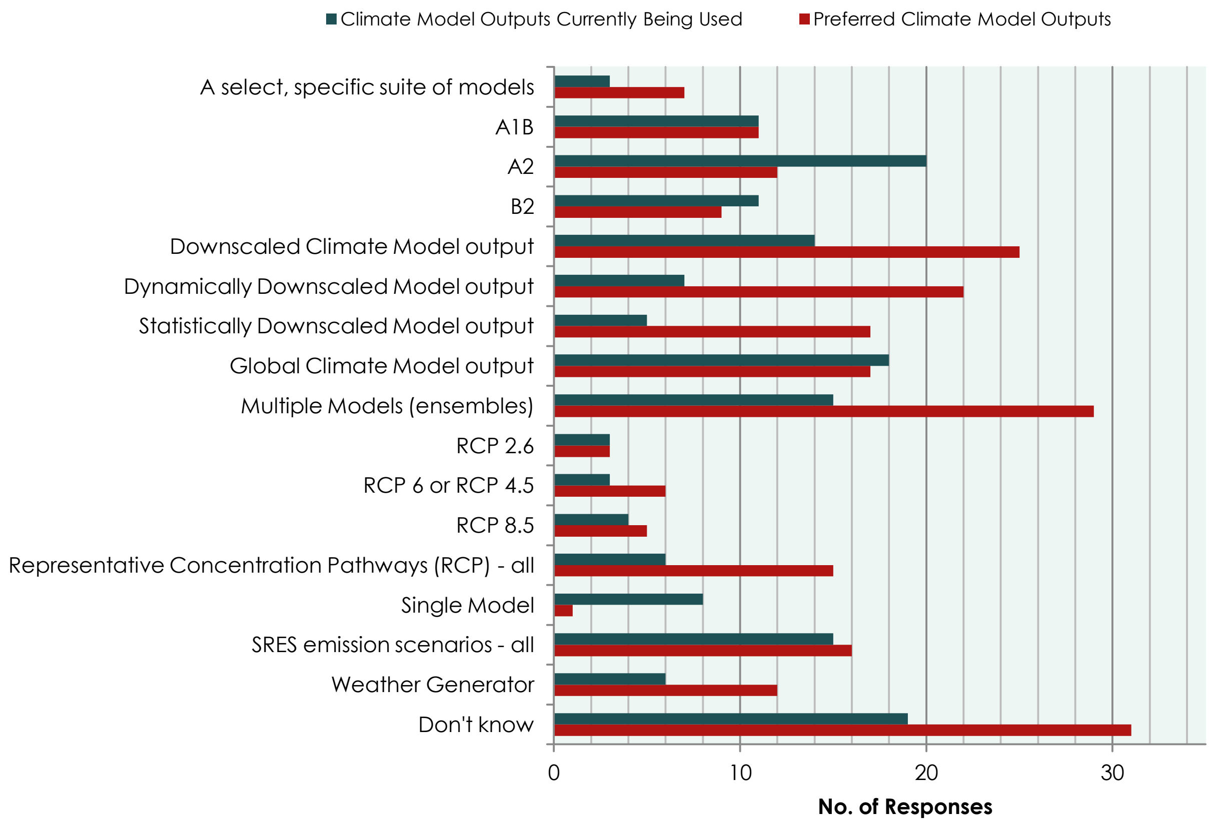


2.6 CLIMATE MODELS

This section reports on preferences for aspects of climate models and their output. Survey results show that the A2 GHG emission scenario is most in use and outputs from global models prevail. When asked to identify their preferences, respondents identified using multiple models (ensembles) and downscaled climate model outputs as their top choices.

- Figure 8 below shows the results of uses and preferences for climate model outputs.
- An almost equal number of respondents use downscaled model results as global model results (14 vs. 18), but the preference for downscaled results is much higher (25 vs. 17).
- The use of SRES GHG emission scenarios varies only slightly within the suite. That is, A2 is used only slightly more that less GHG intense scenarios.
- The use of multiple models outweighs the use of single models in both the actual and preferred options.
- There is much less uptake on using the new Representative Concentration Pathways (RCPs) compared to SRES scenarios, but both are equally preferred.
- Many respondents did not know what type of climate model outputs they currently use, and a few respondents identified that they do not currently use climate model outputs.
- 5 survey respondents identified the need for hydrological model outputs.
- Many of the respondents did not know what type of climate model outputs would be preferred in their line of work, and a few expressed that they are not familiar with the definition of the climate model outputs listed in the survey and were therefore unable to answer.
- A respondent from the municipal government stated that they have no preference as to which climate model output they use. However, they need to commit to using climate models, downscale them for local/regional conditions, and develop appropriate hydrologic models to predict extreme peaks, changes in infiltration and inflow into sanitary systems, and use them to better understand changes to the frequency of extreme events.

FIGURE 8 | Current vs. preferred climate model outputs



2.7 Uncertainty

This section identifies whether the survey respondents have accounted for uncertainty associated with climate model output, and whether or not they see a need to account for this uncertainty. Further, this section identifies respondent's level of understanding of climate model uncertainty, and how important accounting for this uncertainty is in their line of work. Finally, this section identifies some of the preferred methods to help improve the level of understanding of uncertainty in this context.

Most respondents state that they are somewhat (or more) knowledgeable about climate model uncertainty and suggest that accounting for and quantifying this uncertainty is important. Web-based material accompanying climate model data information products is the preferred method to help improve the level of understanding of the uncertainty associated with climate model output.

- 85% of the survey respondents see a need to account for uncertainty associated with climate model output, yet only 68% are currently accounting for uncertainty.

- When asked to rate their understanding of the uncertainty associated with climate model output, most of the respondents claim to be knowledgeable or somewhat knowledgeable on the subject (see Figure 9).
- Figure 10 shows that most of the survey respondents (73%) consider accounting for and quantifying uncertainty associated with climate model output as either important (43%), very important (21%) or extremely important (9%). Only 4% of respondents considered accounting for uncertainty to be unimportant, while 10% thought it is neither important nor unimportant. 13% of the respondents were unsure of the importance of accounting for and quantifying uncertainty.
- When asked what could help to improve the level of understanding of the uncertainty associated with climate model output, the survey respondents identified web-based material accompanying climate model data information products as the preferred method (see Figure 11 below).
- The respondents also identified tutorials/webinars, and to a lesser extent, special in-person training, as ways to improve their level of understanding of uncertainty.

FIGURE 9 | Understanding of the uncertainty associated with climate model output

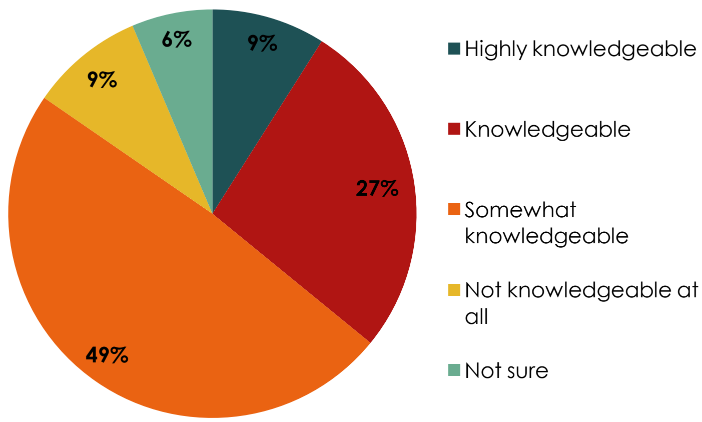


FIGURE 10 | Importance in accounting for and quantifying uncertainty associated with climate model output

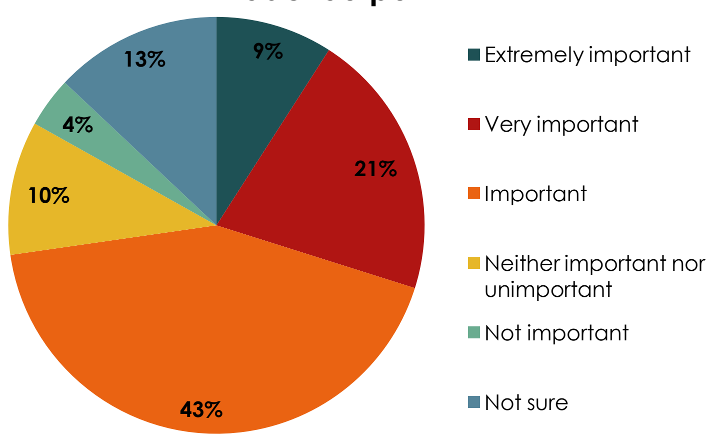
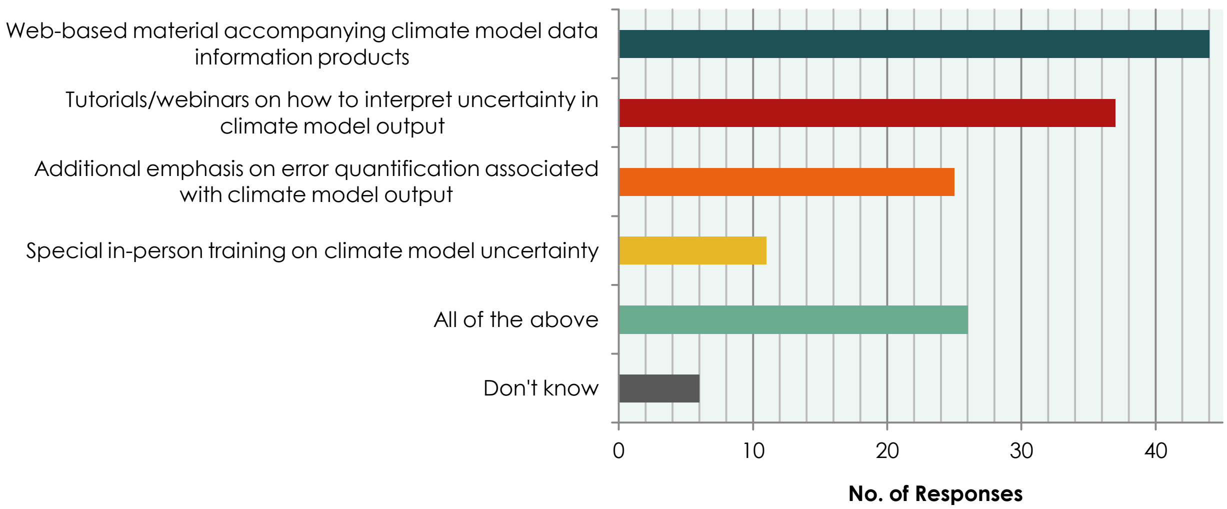


FIGURE 11 | What would help improve the level of understanding of the uncertainty associated with climate model output



2.8 Climate Data

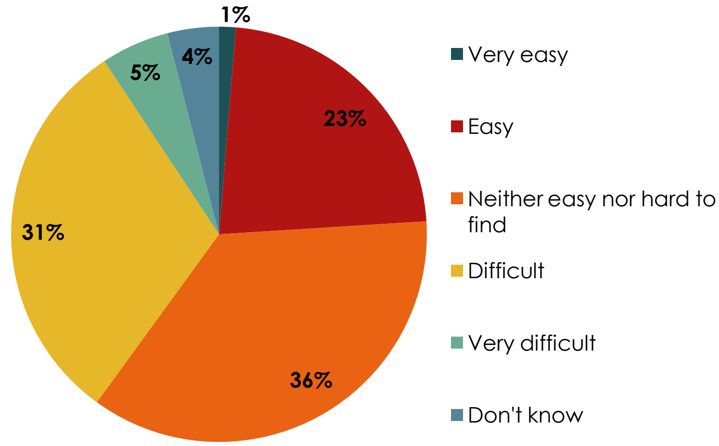
Questions on climate data asked how easy it was to find climate data (historical or future projections) within the survey respondents' line of work. Historical data is discussed, including: the most useful types of historical climate data, which organizations are consulted in order to obtain historical climate data, the quality of user/application guidance materials, the quality of the data obtained, and how historical climate data is used. Further, climate change projections are discussed, including: which organizations are consulted in order to obtain climate projections, the quality of the user/application guidance materials, how data sets are accessed, and how climate change projections are used. Additionally, this section summarizes the opportunities the survey respondents saw for climate change projection data.

Most of the respondents expressed that it is neither easy nor hard to find climate data, however a large portion of the respondents identified that it is difficult. The organization most consulted to obtain historical climate data and climate projections was Environment Canada. All types of historical climate data and products including climate trends, climate normals, records of isolated events and historical time series were considered equally useful, and most of the respondents found that historical climate data was of high quality. For climate projections, most of the respondents accessed climate projection data through publicly available data sets/products, and climate projections are used for many reasons (the number one reason being the development of adaptation plans).

Respondents noted the need for continued improvements to the spatial resolution of climate data while also recognizing the need for clear statements about levels of uncertainty and limitations in the data.

- Figure 12 demonstrates that most of the survey respondents consider finding climate data appropriate for their line of work to be neither easy, nor hard to find.
- Although 23% of respondents identified that finding climate data is easy, some find it difficult (31%). Some of the respondents explain why:
    - Sometimes it is hard to get hourly precipitation data for hydrologic model runs.
    - It is difficult to get dynamically downscaled data.
    - There is general data available for climate parameters, but more specific data is needed for water management models.
    - Although monthly temperature and precipitation data are generally easy to find, daily can be more difficult.
    - Wind and solar radiation are harder to get in accessible daily forms.
    - Much of the day-to-day climate data that was available from Environment Canada stations has been mothballed and the ongoing stations can be very slow at providing relevant data.
    - One respondent explained that finding climate data is easy enough, but the confusion over the pros and cons of various data sets is the difficult part.

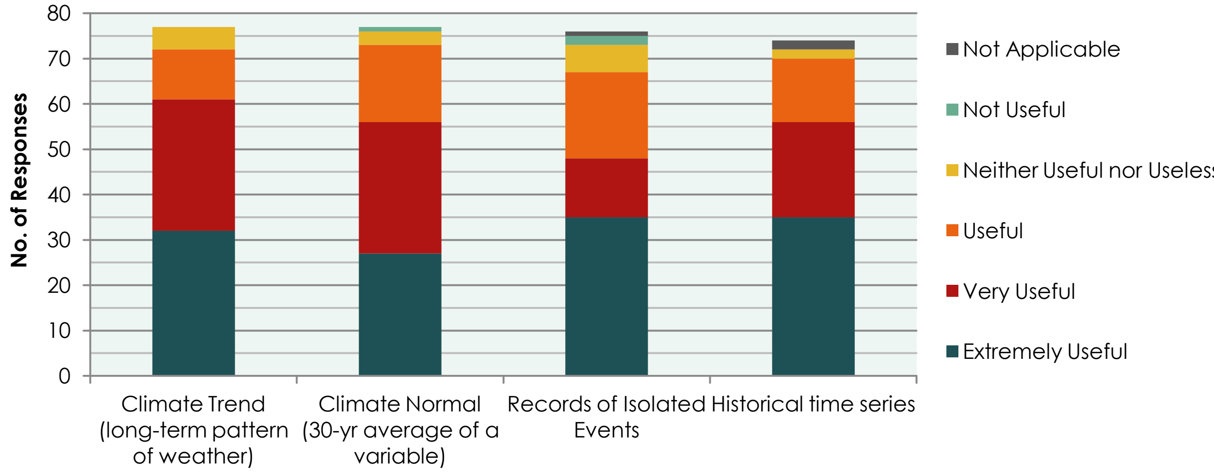
FIGURE 12 | Ease of finding climate data



2.8.1 Historical Climate Data

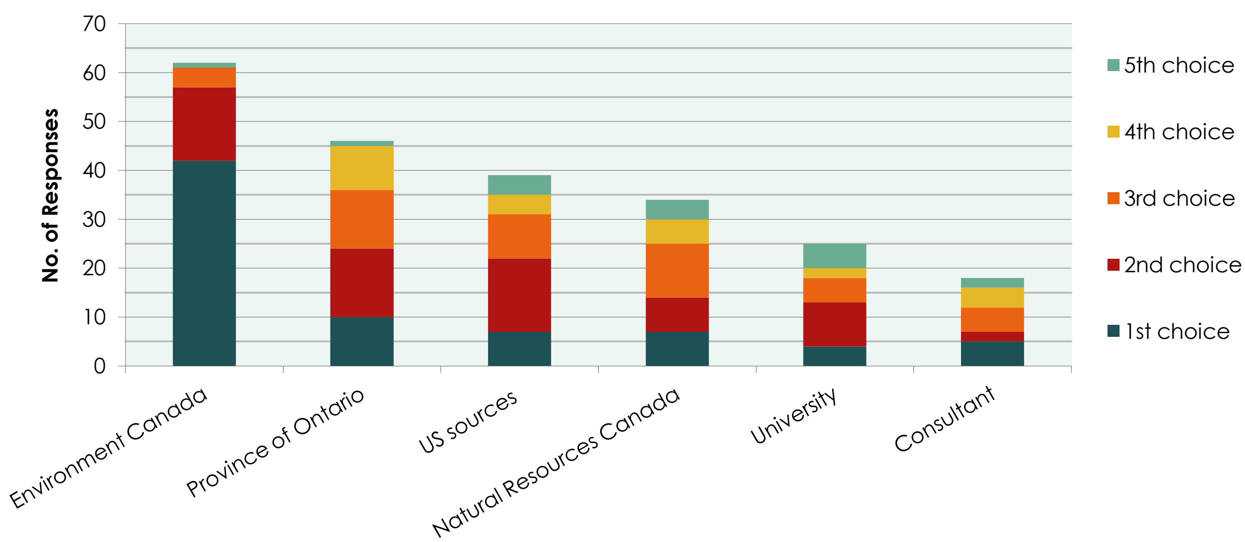
- Figure 13 (below) identifies results on the usefulness of different types of historical climate data. Each of the four types of historical data/products was considered useful, very useful or extremely useful. Very few survey respondents considered them not useful.
- A survey respondent that identified all four types of historical climate data as extremely useful stated that it all depends on the accuracy, reliability and completeness of the data, and the statistics used to create the secondary information.

FIGURE 13 | Usefulness of historical climate data



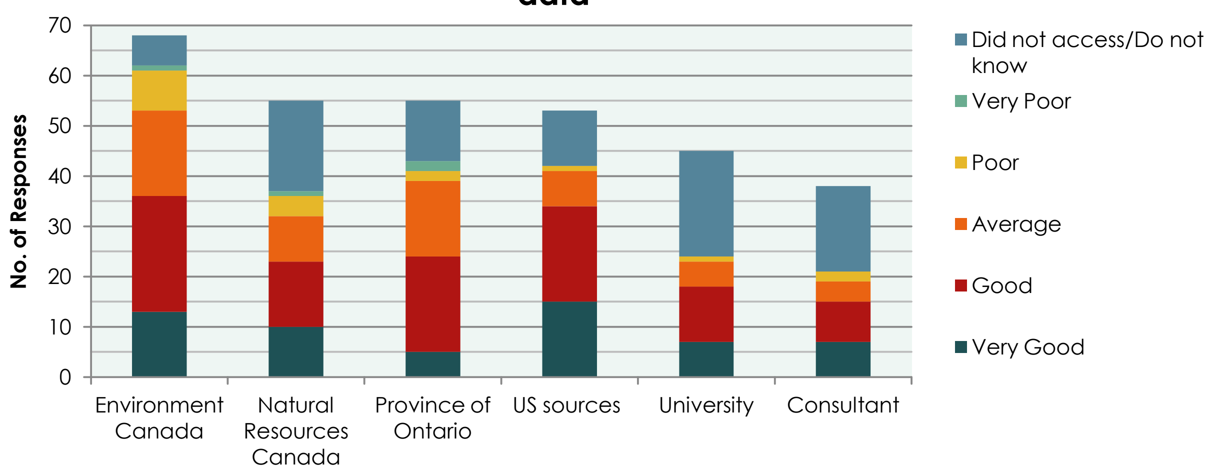
- Figure 14 identifies the organizations survey respondents usually consult in order to obtain historical climate and weather data. There is a clear indication that Environment Canada is consulted most frequently.
- Some respondents listed other organizations that they use to obtain historical climate and weather data:
    - Intergovernmental Panel on Climate Change (IPCC)
    - ICLEI – Local Governments for Sustainability
    - Ontario Climate Consortium (OCC)
    - Agriculture and Agri-Food Canada (AAFC)
    - Local municipality/internal city records

FIGURE 14 | Organizations consulted to obtain historical climate and weather data



- Figure 15 shows results from a question asking about the quality of the user/application guidance that is provided with the material from the historical data sets. Respondents say that the best guidance is provided by US sources as well as Environment Canada, though each organization received ratings of mostly very good, good or average.
- Only a few respondents identified the guidance materials as poor or very poor, particularly in the case of Environment Canada, Natural Resources Canada, and the Province of Ontario.
    - One of the respondents stated that they rated Environment Canada as poor because of the challenges associated with downloading batches of historical data.
    - Another respondent mentioned that Environment Canada data is progressively getting worse, with stations being shut down, long intervals between data updates, etc.
- Some of the survey respondents identified additional sources of user/application guidance on historical climate and weather data:
    - Intergovernmental Panel on Climate Change (IPCC)
    - National Agroclimate Information Service of Agriculture and Agri-Food Canada (AAFC)
    - ICLEI – BARC Localizer Reports

FIGURE 15 | Quality of user/application guidance materials from organizations that provide historical climate and weather data



- Figure 16 shows results that signal whether the historical climate data used by the respondents was of sufficient quality in order to be useful for decision-making (i.e. complete, quality checked, homogenized, spatially representative).
- Most of the respondents (44%) found that historical climate data was frequently of high quality, followed closely by 35% of respondents who found that historical climate data was occasionally of high quality.

- Another response explained that historical climate data is used with little regard for levels of quality.
- Figure 17 shows the ways in which historical climate data is used in the work.
- Some of the survey respondents identified additional ways that they use historical climate data:
    - For research;
    - As guidance for operational decisions;
    - Crop yield forecasting model inputs;
    - Matching to existing non-climate datasets for the purposes of modeling ecological responses to climate; and
    - Informing program planning for health (e.g. heat alert and response plan, cold weather plan).

FIGURE 16 | How often historical data was of sufficient quality

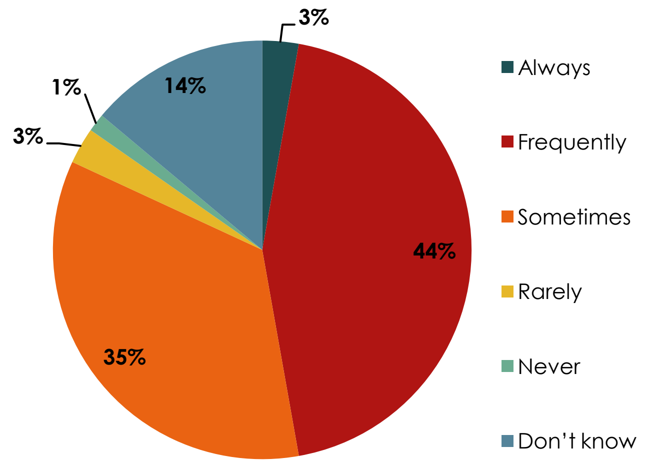
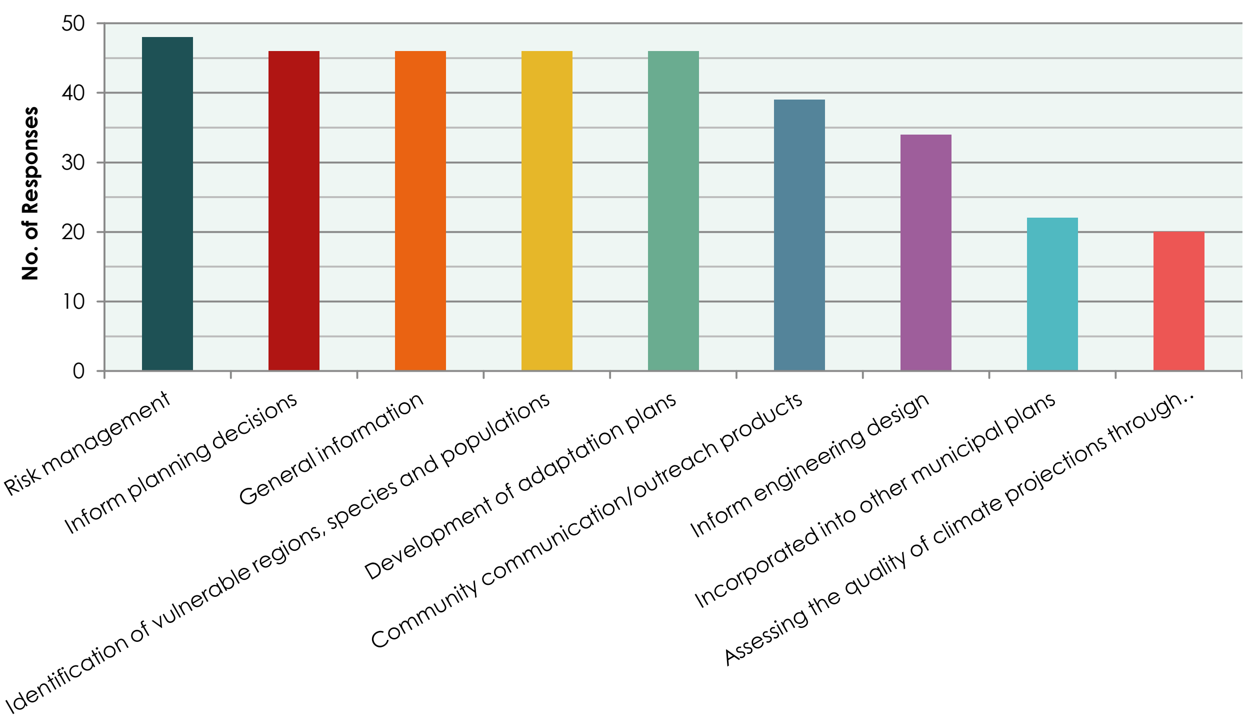


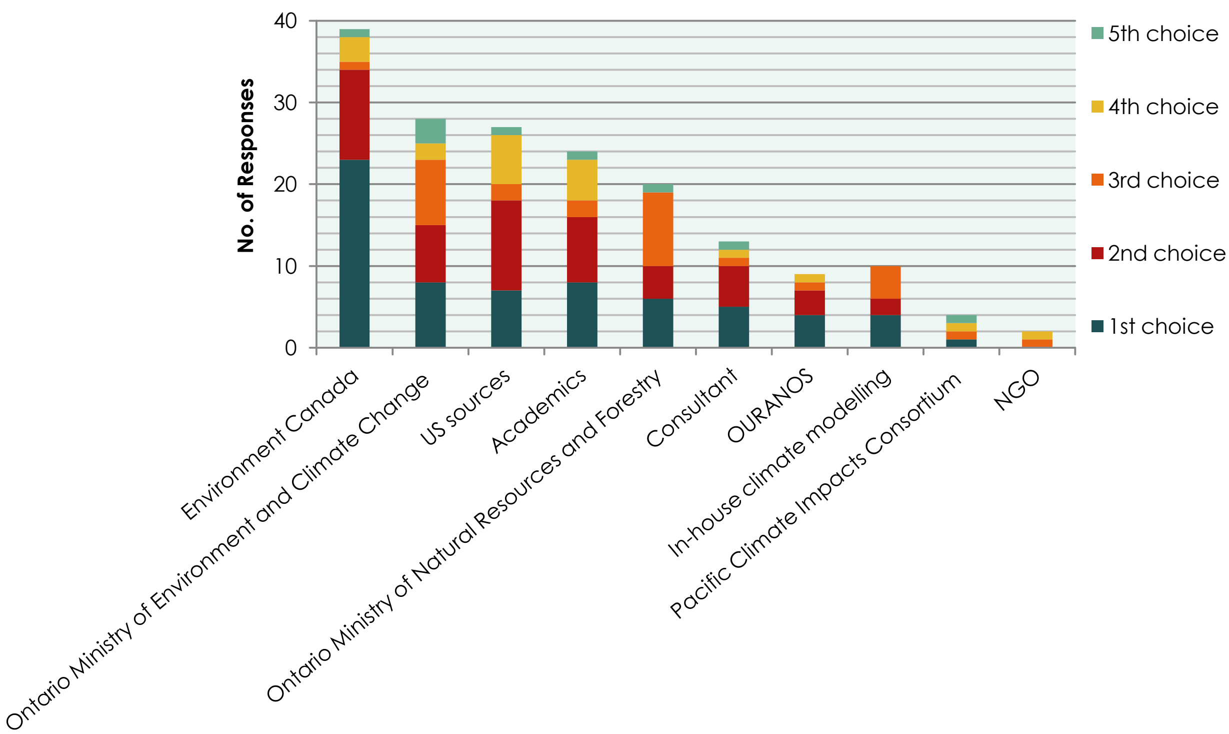
FIGURE 17 | How historical climate data is used



2.8.2 Climate Projections

- Figure 18 identifies which organizations survey respondents consult in order to obtain climate change projections. Environment Canada is the most highly consulted, followed by the Ontario Ministry of Environment and Climate Change and US sources.
- Some respondents listed other organizations that they use to obtain climate change projections:
    - Intergovernmental Panel on Climate Change (IPCC)
    - Agriculture and Agri-Food Canada (AAFC)
    - Toronto and Region Conservation Authority (TRCA)
    - Canadian Institute of Forestry (CIF)
    - Local municipalities

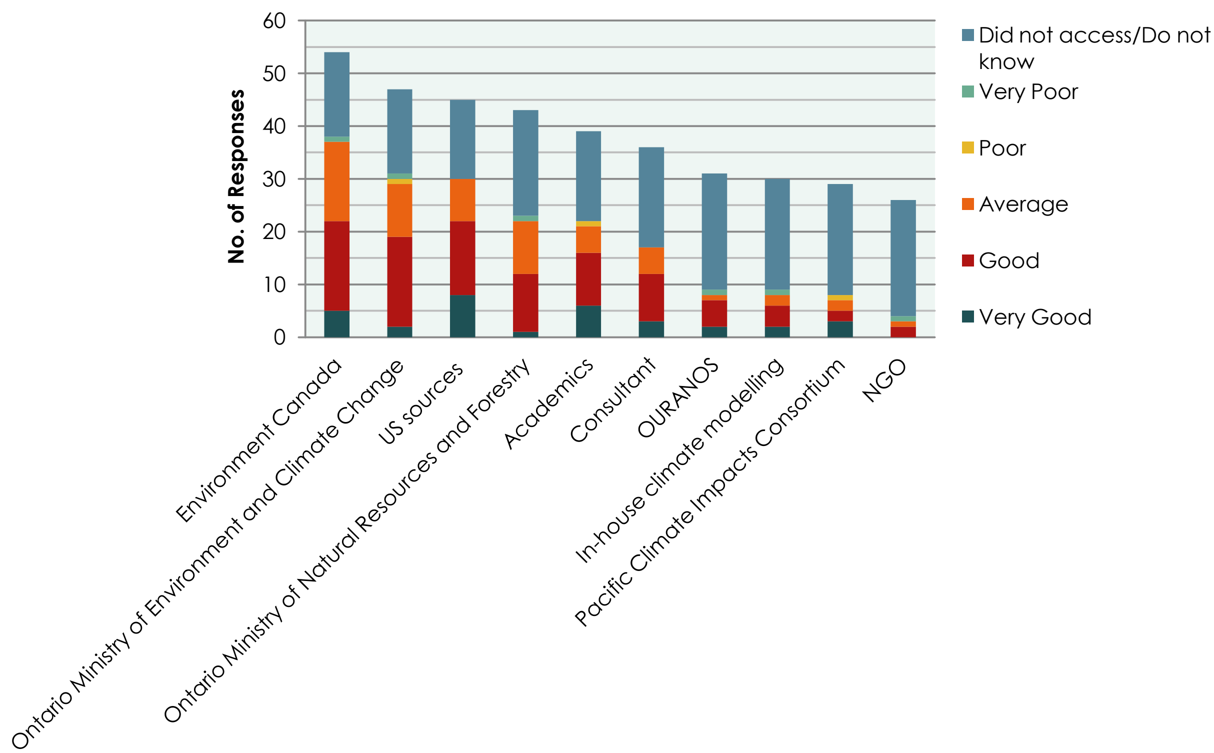
FIGURE 18 | Organizations consulted to obtain climate change projections



- Figure 19 below identifies comment on the quality of the user/application guidance that is provided with the climate change projections. It is evident that the best guidance is provided by US sources, Environment Canada, and the Ontario Ministry of Environment and Climate Change.
- Very few of the organizations were ranked as “poor” or “very poor” in terms of climate projection guidance material, but many respondents have not previously accessed climate change projections or were unsure how to answer the question.

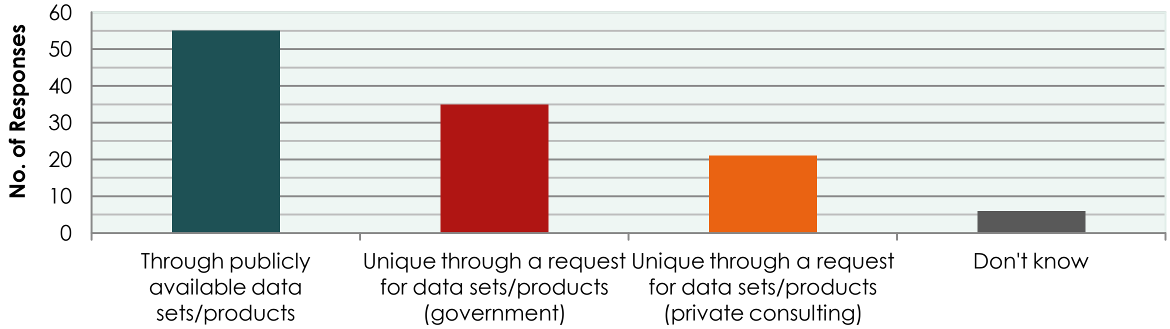
- Some of the survey respondents identified additional sources of user/application guidance on climate projections:
    - Intergovernmental Panel on Climate Change (IPCC)
    - Canadian Forest Service (CFS)
    - The Hadley Met Office provides climate projection guidance material (some good, some not so good)

FIGURE 19 | Quality of user/application guidance materials from organizations that supply climate projections



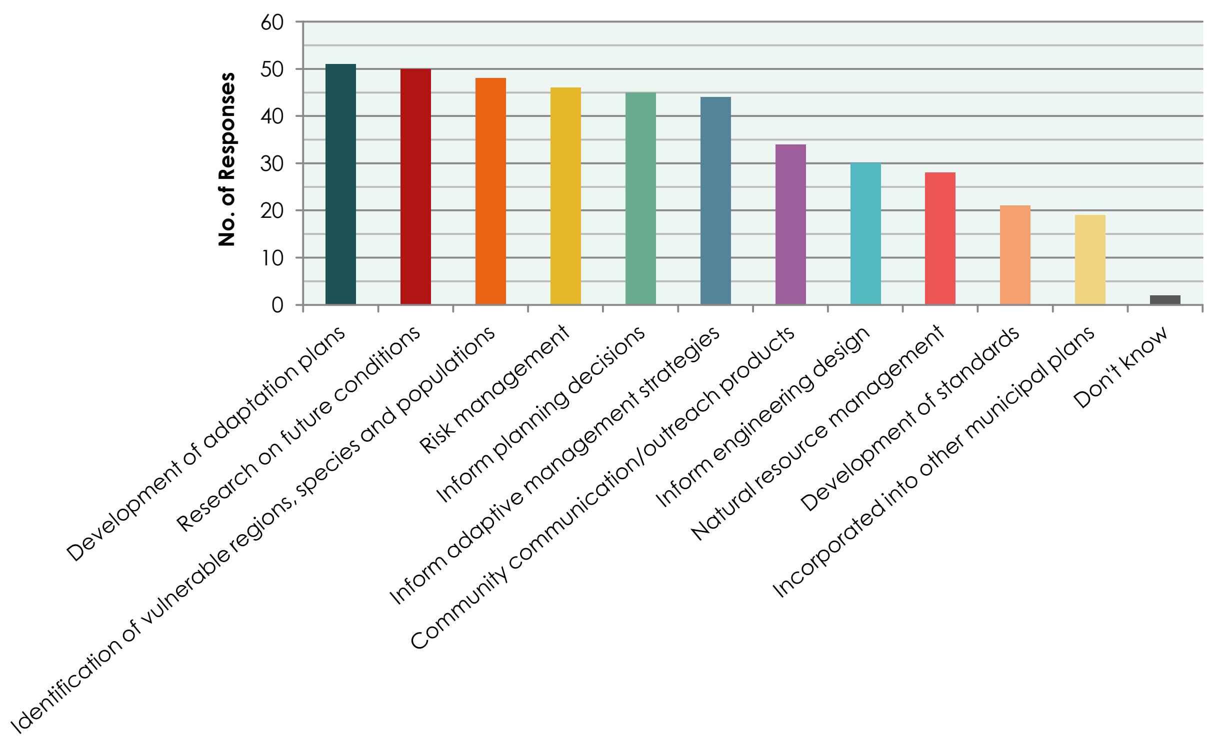
- Figure 20 below shows that most of the respondents access their climate projections through publicly available data sets/products, followed by requests to either government or private consulting firms.
- Some respondents identified additional locations to access data sets:
    - ICLEI – BARC program
    - Academic resources

FIGURE 20 | How data sets are accessed



- Figure 21 shows the ways in which climate change projections are used in the work of the survey respondents. It is clear that many of the methods listed are used by the survey respondents, yet the top three methods include:
    - Development of adaptation plans
    - Research on future conditions
    - Identification of vulnerable regions, species and populations
- Some of the survey respondents identified additional ways that they use historical climate data, including research, flood forecasting and warning, and to advocate for action and resources to prevent climate-related health impacts.

FIGURE 21 | How climate change projections are used



2.8.3 Opportunities for Climate Change Projection Data

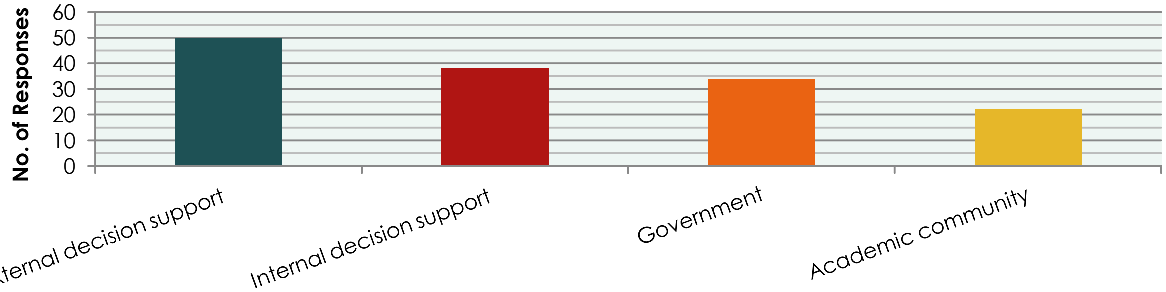
- When asked about opportunities for use/application of climate change projection data, respondents noted the need for continued improvements to the spatial resolution of climate data while also recognizing the need for clear statements about levels of uncertainty and limitations in the data. It was suggested that more guidance be provided on uncertainty and how to include uncertainty in risk management decision-making.
- The respondents mentioned that there is a need to explicitly state the connections to local impacts which would allow decision-makers to better understand not just the impacts, but critical thresholds, beyond which risk levels increase.
- Respondents also noted the need for consistency in aspects of data reporting (and within the information products), including a standard for baseline periods and projection periods as well as changes relative to global average change.
- One of the respondents suggests that data be accessible to those who may not have a technical background. This includes placing the data into user-friendly formats that are accessible to the lay audience (e.g. summary materials and figures, and graphics that communicate key points quickly and easily). This could potentially include visualization of projection data.
- The need to have climate data reflected in infrastructure codes and standards was mentioned repeatedly.

2.9 Climate Information Products

This section identifies the audience the survey respondents aim to target with climate information, and rates the usefulness of a variety of climate information products. Most of the respondents use data to support decisions outside of their organizations. Some of the most useful climate information products include analysis of extremes, maps of future changes and values, historical trends, analysis of IDF curves, and time series.

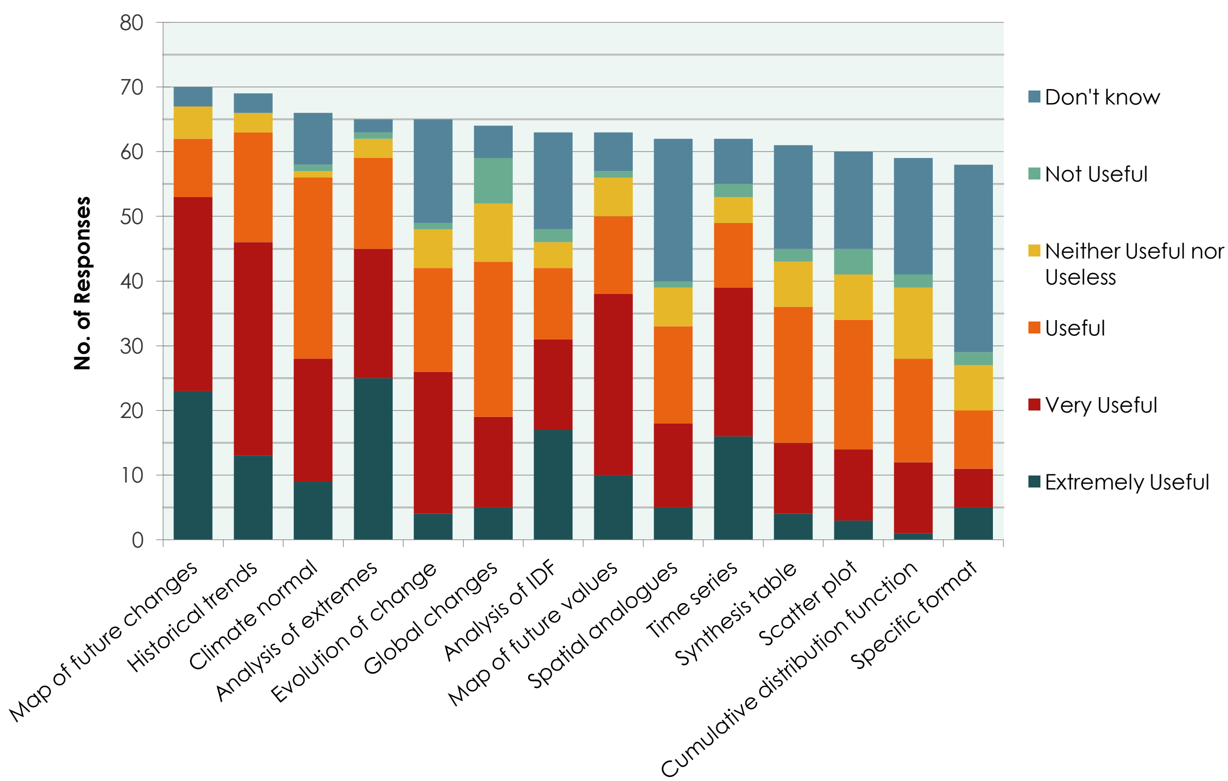
- When asked to describe the target audience of their work, most of the respondents identified that the purpose of their work is to support decisions outside of their organization, followed closely by internal decision support and supporting government (see Figure 22).

FIGURE 22 | Target audience



- Figure 23 shows ratings for usefulness of certain climate information products. Ranking high in terms of "extremely useful" or "very useful" are:
    - Analysis of extremes
    - Map of future changes
    - Historical trends
    - Map of future values
    - Time series
    - Analysis of IDF
- Some of the climate information products with the highest number of votes for "not useful" include global changes and scatter plots.

FIGURE 23 | Usefulness of climate information products



3.0 CONCLUSION

Climate change is a complex issue requiring full analysis of the magnitude of previous change and projections of future change for a variety of different variables. Connections to impacts are also often unclear and confounded by alternate stresses on natural and built systems. In the context of vulnerability and risk assessments and adaptation planning frameworks, high quality, timely, robust and available climate information help to support climate sensitive decision-making in many fields of study and across many aspects of society.

Increasingly, stakeholders across Ontario are searching for both general and specific climate information to support adaptation decisions at community, watershed, regional and site levels. Climate data is collected, treated and distributed by a wide variety of organizations and agencies including federal and provincial government departments, local stewardship groups, NGO's and researchers. In this setting, it can be difficult for end-users to find the most appropriate climate data for their specific decision-making needs. To be most effective, climate service development and delivery should be guided by the needs of the stakeholders.

This survey serves to gauge current uses of, and needs for, climate information in end-user groups such as government, academics, and Conservation Authorities. Results are meant to help climate information development and delivery groups hone their products in order to support adaptation planning in Ontario and beyond.

APPENDIX

Table 3 | Main survey themes and associated survey questions	
Theme	Survey Questions
Type of Respondent	1. What type of organization do you represent? 2. What sector are you working in? Select all that apply. 5. How much experience do you have in applying climate model output to your decision making? 6. How important are climate models to your decision making?
Climate Hazards and Impacts	3. Which facets of climate change hazards does your organization seek to manage for? Please select all that apply. 4. Which climate change impacts is your organization most concerned with?
Climate Variables	7. How important are the following climate variables in your work?
Climate Model Resolution	8. What climate model spatial resolution would be preferred for application to your work? 9. Why do you feel this resolution is necessary? 10. What climate model spatial resolution would be useful for application to your work? 11. What would you be unable to accomplish if this was the only resolution available?
Timeframes and Time Intervals	12. To what future timeframes do you plan for in your job? Please check all that apply. 13. Please indicate what weather/climate data time intervals are preferred for your work.
Climate Models	16. Which climate model outputs (e.g. models, scenarios, etc) do you currently use in your work? Select all that apply. 15. Which climate model outputs (e.g. models, scenarios, etc) would you prefer to use in your work? Select all that apply.
Uncertainty	17. Do you account for uncertainty associated with climate model output? 18. Do you see a need to account for uncertainty associated with climate model output? 19. Please rate your understanding of the uncertainty associated with climate model output. 20. How important is it in your work to account for and quantify uncertainty associated with climate model output? 21. What would help improve your level of understanding of the uncertainty associated with climate model output? Please check all that apply.
Climate Data	22. Please indicate how easy it is to find climate data that is appropriate for your work?
Historical climate data	14. How useful are the following types of historical climate data in your work? 23. Which organizations do you consult in order to obtain historical climate and weather data? Please rank based on use (e.g. 1 for the organization you use most, etc). 24. Thinking about the following data sets you have accessed in order to obtain historical climate and weather data, please rate the quality of user/application guidance that is provided with the material. 28. Was the historical data of sufficient quality (i.e. complete, quality checked, homogenized, spatially representative) to be useful for your decision-making context? 31. How is historical climate data used in your work? Please select all that apply.

Climate Change Projections	25. Which organizations do you consult in order to obtain climate change projections? Please rank based on use (e.g. 1 for the organization you consult most, etc).
	26. Thinking about the following data sets you have accessed in order to obtain climate change projections, please rate the quality of user/application guidance that is provided with the material.
	27. How do you access the data sets that you use? Check all that apply.
	32. How are climate change projections used in your work? Select all that apply.
Opportunities for Climate Change Projection Data	33. What, if any, opportunities do you see for climate change projection data (e.g. how can this information be 'decision-ready' or applied)?
Climate Information Products	29. Which of the following options best describes the target audience of your work?
	30. In the context of your work, how useful are the following climate information products?

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