Climate Science Report for the Climate Change and Health Vulnerability Assessment

For Oxford County, Elgin County and the City of St. Thomas

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Glossary

Baseline

A climatological baseline is a reference timeframe, usually spanning three decades (30 years), that is used as a comparison point for the climate variations between different periods. References and reference periods are also known as baselines.

Climate Change

Climate change refers to the long-term changes in the weather due to natural phenomena and increased human activities. This leads to changes in the atmospheric gas's composition due to accumulation of greenhouse gases.

Climate Projections

Climate projections are estimates of how the climate system will likely respond to different greenhouse gas and aerosol emissions or concentration scenarios. These projections rely on the climate change or emissions scenarios, which are developed based on assumptions regarding upcoming socioeconomic and technological advancements that may or may not materialize. Therefore, there is an element of uncertainty.

CMIP6

The Coupled Model Intercomparison Project Phase 6 (CMIP6) global climate models (GCMs) have climate scenarios used in the latest Intergovernmental Panel on Climate Change Sixth Assessment Report. These models provide climate projections that are built upon the Shared Socio-economic Pathway (SSP) scenarios. The CMIP6 projections serve as a foundation for understanding and predicting future climate conditions.

Ensemble Approach

The ensemble approach can be used to determine temperature and precipitation patterns using the average data from all global climate models (GCMs). Studies have shown that using multiple models instead of relying on one produces more accurate predictions of annual and seasonal temperature and precipitation.

Ensemble Mean

Ensemble mean refers to the average value of the climate projections examined in the study.

Extreme Weather Event

This refers to a meteorological occurrence that surpasses the typical range of activity, and is rare in a particular place and season, such as a severe storm, hailstorm, tornado, heatwave, or flood. An extreme weather event typically occurs very infrequently or has a probability that is in the bottom 10%.

General Circulation Models

General Circulation Models (GCMs) are mathematical representations of the atmosphere, ocean, land surface and ice caps that are based on physical laws and relationships derived from empirical data. These models are the sole means to consistently estimate climate changes caused by increased greenhouse gases for a wide range of climate variables.

Greenhouse Gas (GHG) Emissions

Greenhouse gases refers to the atmospheric gases, originating from both natural and human activities, that can absorb and release radiation at specific wavelengths within the thermal infrared spectrum. This includes radiation emitted by the Earth's surface, the atmosphere, and clouds. There are six main greenhouse gases: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulphur hexafluoride.

IPCC

Intergovernmental Panel on Climate Change. The IPCC is an international body under the administration of the United Nations. It was created to evaluate and assess scientific research on climate change, and regularly releases authoritative assessment reports that address various aspects, including the science of climate change, its impacts, and policy options for adaptation and mitigation.

Radiative Forcing

Radiative forcing is the change in the net radiative flux, that represents the difference between incoming and outgoing flux, at the top of the atmosphere due to some changes in an external driver of climate change such as greenhouse gases.

Shared Socioeconomic Pathways (SSP)

The IPCC for its Sixth Assessment Report (AR6) in adopted five trajectories known as Shared Socioeconomic Pathways (SSPs), which represent different greenhouse gas concentration levels.

SSP1-2.6

The projected greenhouse gas concentrations are at a low level, with low challenges to mitigation and adaptation. It indicates a 2.6W/m^2 rise in radiative forcing in the climate system.

SSP2-4.5

The projected greenhouse gas concentrations are at a moderate level, with medium challenges to mitigation and adaptation. It corresponds to a 4.5W/m^2 increase in the radiative forcing on the climate system.

SSP5-8.5

The projected greenhouse gas concentrations are characterized by a heavy reliance on fossil fuels and significant challenges in terms of mitigating climate change, but low challenges to adaptation. It represents an 8.5W/m^2 increase in radiative forcing on the climate system.

U/V index

It is the invisible electromagnetic radiation that has a frequency range between x-rays and visible violet light. While the ozone layer in the atmosphere absorbs majority of the ultraviolet radiation from sunlight, UV-B radiation can result in sunburn and skin cancer, while UV-A radiation can induce photosensitivity reactions and potentially lead to skin cancer.

W/m²

Watts per square meter is a unit that measures the rate at which one watt of heat energy is transferred over a one square meter area. Radiative forcing is calculated using this unit.

Introduction

The aim of the climate science report is to provide a summary of climate-related data for the regions of Oxford County, Elgin County and the City of St. Thomas. The report outlines climate change projections to support the Climate Change and Health Vulnerability Assessment for Southwestern Public Health. It is intended to assist in identifying potential risks and vulnerabilities that may affect these areas due to climate change and to inform the public health stakeholders in the region on how to prepare for the projected health effects of climate over time.

Climate Indices

The table below presents the definition of climate indices. These indices entail a wide range of significant climate variables that have the potential to affect the study area. The Climate Data Canada was used to gather data on temperature and rainfall (excluding freezing rain), as well as the names and descriptions of the climate indices.

Table 1: Climate Indices Definitions

Climate variable	Climate indicator	Definition	Unit
Temperature	Mean Monthly Temperature	The average temperature for a specific month	°C
	Mean Monthly Maximum Temperature	The average monthly maximum temperature	°C
	Mean Monthly Minimum Temperature	The average monthly minimum temperature	°C
	Extreme Heat Days	The number of days where the daytime temperatures exceed 30°C and 32°C	Days
	Extreme Cold Days	The number of days with daily minimum	Days

		temperatures is <-15°C	
	Tropical Nights	The total number of days in a year when the daily minimum temperature exceeds 20°C	Days
	Frost Days	The total number of days with frost potentials (i.e., minimum temperature below 0°C)	Days
	Ice Days	The total number of days suitable for ice formations (i.e., when daily maximum temperature is below 0°C)	Days
	Extended Heat Wave Frequency	The total number of extended heat wave occurrences in a year. An extended heat wave is characterized as three consecutive days with Tmax >31°C and Tmin >20°C	Times/year
Precipitation	Total Precipitation	Total accumulated precipitation	mm
	Maximum Length of Dry Spell	The longest dry period in a year	Days

		corresponds to the highest consecutive number of days when the daily precipitation remains below 1mm	
	1-Day Maximum Precipitation	Annual 1-day maximum precipitation accumulation	mm
	5-Day Maximum Precipitation	Annual 5-day maximum precipitation accumulation	mm
	Very Wet Days (10mm)	The number of days within a specific timeframe where the total precipitation, which includes both rain and snow, exceeds or equals 10 mm	Days
	Extremely Wet Days (20mm)	The number of days within a specific timeframe where the total precipitation, which includes both rain and snow, exceeds or equals 20 mm	Days
	Freezing Rain Events	The average percentage variation in the number of daily freezing rain events	Days

		(≥1 hour, ≥4 hours, and ≥6 hours)	
Air Quality	Ground-level Ozone	The amount of ground level ozone in the air at a given location, which is generated when nitrogen oxides react with a category of air pollutants referred to as ‘reactive organic substances’ under sunlight	Ppb or as indicated
	Particulate Matter	The quantity of suspended matter (including aerosols, smoke, fumes, dust, fly ash, and pollen) in the air, which can vary in size between PM2.5 and PM10	µg/m³ or as indicated
	Nitrogen Dioxide	The amount of nitrogen dioxide in the air at a given location	Ppb or as indicated
UV radiation	UV index	Strength of sunburn-causing ultraviolet (UV) radiation in a specific location and time	UV index

Data Collection

The Climate Data Canada[1] portal was used for majority of the data collection for this report. Qualitative data related to freezing rain, air quality, and UV index were sourced from diverse reports, as these indices were not accessible on the Climate Data Canada portal. When appropriate, these sources were identified and cited correctly. All data were downloaded from the corresponding links above in May 2023.

Climate Modelling and Downscaling

The data used in the report relies on the global climate models established in the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (AR6), that were derived from the Coupled Model Intercomparison Project Phase 6 (CMIP6). These models incorporate assumptions about the future changes in population growth, education, energy usage, technological advancements, and other relevant factors for the next century. These assumptions are then combined with mitigation and adaptation efforts in climate change. By integrating socio-economic factors and mitigation goals, these models generate scenarios that reflect projected greenhouse gas emissions and their corresponding atmospheric concentrations, that are known as the Shared Socioeconomic Pathways. Temperature and precipitation projections have been summarized and presented using the Climate Data Canada as sources of data.

Although different methods exist to create climate change scenarios, global climate models are the most comprehensive tools for simulating responses to rising greenhouse gas concentrations, as they employ mathematical representations of atmosphere, ice, ocean, and land surface processes. Climate Data Canada provides historical (1950-2014), and future (2015-2100) climate simulations generated by an ensemble of 24 climate models developed by scientists worldwide.

Greenhouse Gas Emissions Scenarios

As the future emissions of greenhouse gases are influenced by complex and dynamic systems, including factors such as demographic development, socio-economic development, and technological advancement, the emissions are uncertain. Predicting their future trajectory is challenging due to the uncertainty involved. As such, the most recent scenarios utilized for CMIP6

[1] Climatedata.ca is a collaboration between Environment and Climate Change Canada (ECCC), the Computer Research Institute of Montréal (CRIM), CLIMAtlantic, Ouranos, the Pacific Climate Impacts Consortium (PCIC), the Prairie Climate Centre (PCC), and HabitatSeven.

and presented in the IPCC Sixth Assessment Report in 2021 are developed based on a collection of five Shared Socioeconomic Pathways (SSPs). These pathways, namely SSP1-1.9 (very low), SSP1-2.6 (low), SSP2-4.5 (intermediate), SSP3-7.0 (high), and SSP5-8.5 (very high), represent different scenarios of climate change mitigation and adaptation efforts and business-as-usual greenhouse gas emissions in the absence of climate policies. The SSPs five alternative socio-economic futures compromise: sustainable development (SSP1), middle-of-the-road development (SSP2), regional rivalry (SSP3), inequality (SSP4) and fossil-fueled development (SSP5) [1][2]. Scenarios provide alternative representations of future outcomes and serve as crucial tools to determine how driving forces may shape emission patterns and evaluate associated uncertainties.

This report focuses on projections for SSP1-2.6, SSP2-4.5 and SSP5-8.5 as they are available in Climate Data Canada. These scenarios were chosen as they have wide range coverage of possible future climates, incorporate projections from multiple climate models, and have levels of Radiative Forcing that are aligned with the three commonly used Representative Concentration Pathways (RCPs): high (RCP8.5), medium (RCP4.5), and low (RCP2.6). Each emission scenario is described in Table 2, with changes in global surface temperature illustrated in Table 3 and Figure 1 (IPCC, 2021) [3] illustrates the projected global warming for each of these three scenarios.

Table 2: SSP Scenario Descriptions

Scenario	Description
SSP1	**Sustainability - Taking the green road (low challenges to mitigation and adaptation)** The world shifts gradually, but pervasively, toward a more sustainable path, emphasizing more inclusive development that respects perceived environmental boundaries. Management of the global commons slowly improves, educational and health investments accelerate the demographic transition, and the emphasis on economic growth shifts toward a broader emphasis on human well-being. Driven by an increasing commitment to achieving development goals, inequality is reduced both across and within countries. Consumption is oriented toward low material growth and lower resource and energy intensity.

SSP2	**Middle of the road - (medium challenges to mitigation and adaptation)** The world follows a path in which social, economic, and technological trends do not shift markedly from historical patterns. Development and income growth proceeds unevenly, with some countries making relatively good progress while others fall short of expectations. Global and national institutions work toward but make slow progress in achieving sustainable development goals. Environmental systems experience degradation, although there are some improvements and overall the intensity of resource and energy use declines. Global population growth is moderate and levels off in the second half of the century. Income inequality persists or improves only slowly and challenges to reducing vulnerability to societal and environmental changes remain.
SSP3	**Regional rivalry - A rocky road (high challenges to mitigation and adaptation)** A resurgent nationalism, concerns about competitiveness and security, and regional conflicts push countries to increasingly focus on domestic or, at most, regional issues. Policies shift over time to become increasingly oriented toward national and regional security issues. Countries focus on achieving energy and food security goals within their own regions at the expense of broader-based development. Investments in education and technological development decline. Economic development is slow, consumption is material-intensive, and inequalities persist or worsen over time. Population growth is low in industrialized countries and high in developing countries. A low international priority for addressing environmental concerns leads to strong environmental degradation in some regions.
SSP4	**Inequality - A road divided (low challenges to mitigation, high challenges to adaptation)** Highly unequal investments in human capital, combined with increasing disparities in economic opportunity and political power, lead to increasing inequalities and stratification both across and within countries. Over time, a gap widens between an internationally connected society that

	contributes to knowledge- and capital-intensive sectors of the global economy, and a fragmented collection of lower-income, poorly educated societies that work in a labor intensive, low-tech economy. Social cohesion degrades and conflict and unrest become increasingly common. Technology development is high in the high-tech economy and sectors. The globally connected energy sector diversifies, with investments in both carbon-intensive fuels like coal and unconventional oil, but also low-carbon energy sources. Environmental policies focus on local issues around middle and high income areas.
SSP5	**Fossil-fueled development - Taking the highway (high challenges to mitigation, low challenges to adaptation)** This world places increasing faith in competitive markets, innovation and participatory societies to produce rapid technological progress and development of human capital as the path to sustainable development. Global markets are increasingly integrated. There are also strong investments in health, education, and institutions to enhance human and social capital. At the same time, the push for economic and social development is coupled with the exploitation of abundant fossil fuel resources and the adoption of resource and energy intensive lifestyles around the world. All these factors lead to rapid growth of the global economy, while global population peaks and declines in the 21st century. Local environmental problems like air pollution are successfully managed. There is faith in the ability to effectively manage social and ecological systems, including by geo-engineering if necessary.

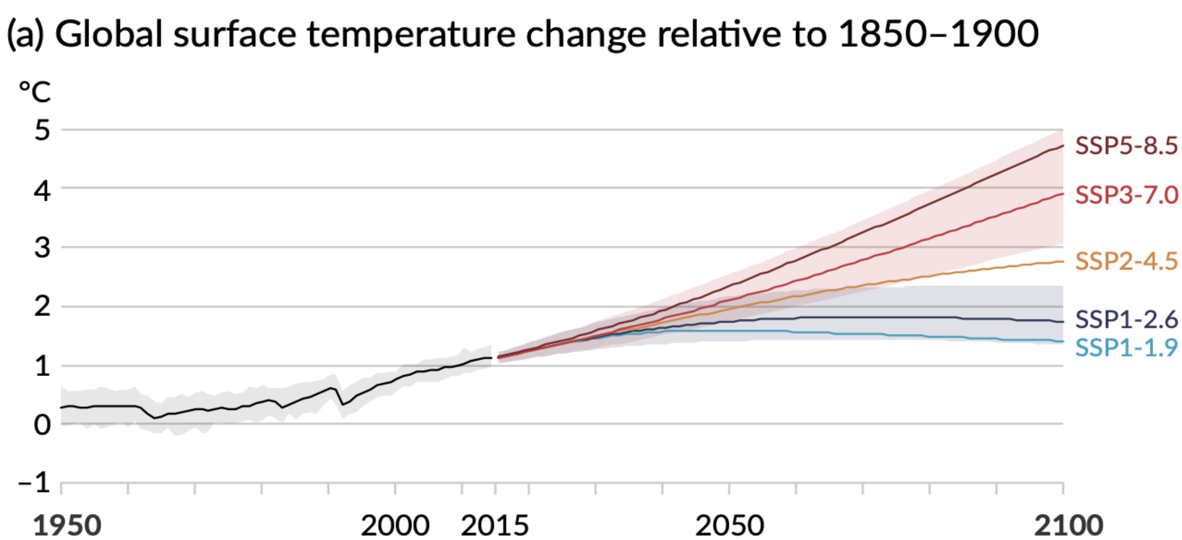
Source: Riahi et al., 2017

Table 3: Changes in global surface temperature for selected 20-year time periods and the five illustrative emissions scenarios considered

	Near term, 2021-2040		Mid-term, 2041-2060		Long term, 2081-2100	
Scenario	Best Estimate (°C)	Very likely range (°C)	Best estimate (°C)	Very likely range (°C)	Best estimate (°C)	Very like range (°C)
SSP1-1.9	1.5	1.2 to 1.7	1.6	1.2 to 2.0	1.4	1.0 to 1.8
SSP1-2.6	1.5	1.2 to 1.8	1.7	1.3 to 2.2	1.8	1.3 to 2.4
SSP2-4.5	1.5	1.2 to 1.8	2.0	1.6 to 2.5	2.7	2.1 to 3.5
SSP3-7.0	1.5	1.2 to 1.8	2.1	1.7 to 2.6	3.6	2.8 to 4.6
SSP5-8.5	1.5	1.3 to 1.9	2.4	1.9 to 3.0	4.4	3.3 to 5.7

Source: IPCC, 2021

Figure 1: Shared Socioeconomic Pathway scenarios (SSP1-1.9, SSP1-2.6, SSP2-4.5, SSP3-7.0 and SSP5-8.5)

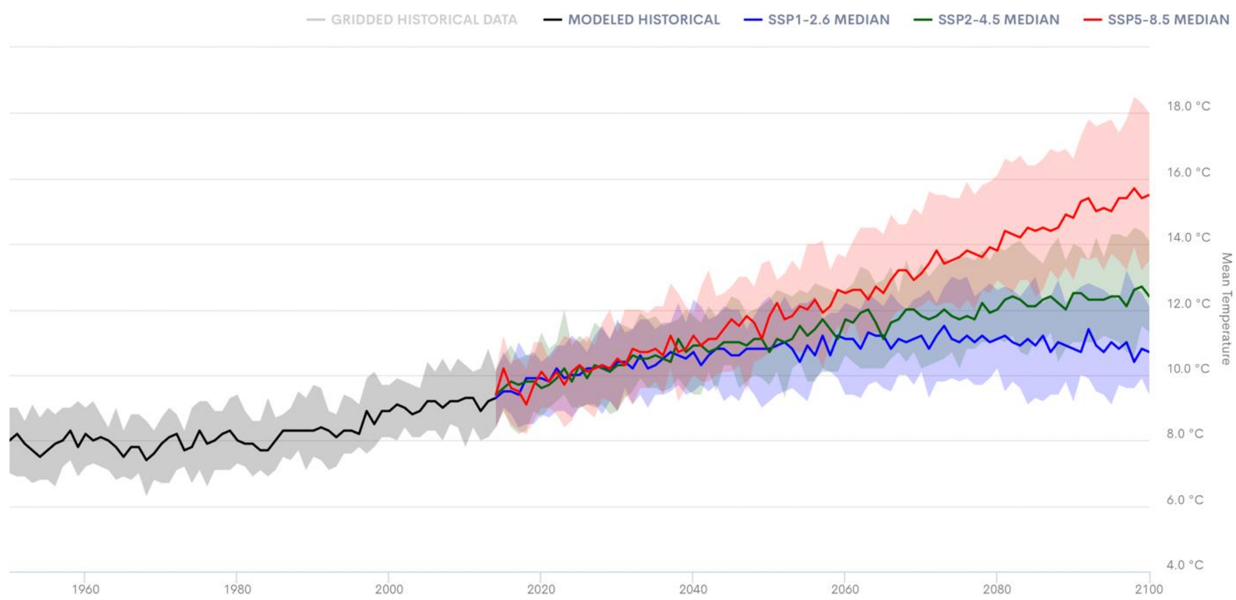


Source: IPCC, 2021

SSP1-2.6 and SSP2-4.5 are presented in the results discussion; however, the primary emphasis is on SSP5-8.5. This scenario is particularly focused on because the impacts of climate change are predicted to be most severe under this scenario across number of important variables. Furthermore, any adaptation strategies created for SSP5-8.5 would likely be sufficient for SSP2-

4.5 and SSP1-2.6. Therefore, the primary goal of highlighting this scenario is to underscore the health risks and their implications for larger populations under higher emissions scenarios. Figure 2 presents Mean Annual Temperature Projections for Elgin County and the City of St. Thomas as an example. The specific emissions path that the future might take remains uncertain. The differences between the SSP1-2.6, SSP2-4.5, and SSP5-8.5 projections highlight the significance of taking into account various emissions scenarios in order to account for a variety of potential future climatic conditions. While the disparity in future projections for various climate indices may not always be as significant as mean annual temperature, in certain cases the differences could be more prominent.

Figure 2: SSP1-2.6, SSP2-4.5, and SSP5-8.5 Mean Annual Temperature Projections for Elgin County and the City of St. Thomas



Source: Climate Data Canada

Timeframes

To effectively compare climate projections with historical patterns, a consistent reference period is established. Climate projections are typically given for specific time periods of 20-30 years. The projected future periods for the data are the 2050s (2040-2069) and the 2080s (2070-2099). The baseline data is from the period between 1986 and 2014 because for CMIP6, the transition from historical simulation to future SSP occurs in 2014/2015.

Certain climate indices such as temperature and precipitation are categorized into different seasons, such as spring, summer, fall, and winter, in addition to providing overall annual measurements or averages. Table 4 outlines the season and its respective months. However, some indices only provide a single value for the year, such as extremes in temperature and other related factors.

Table 4: Seasons and Months

Season	**Months**
Winter	December, January, February
Spring	March, April, May
Summer	June, July, August
Fall	September, October, November

Uncertainty

It is important to recognize that uncertainty is an inherent aspect of studying climate change. Climate change scenarios, models, and data all take uncertainty into account, reflecting the complexity of environmental change and the dynamic relationship between people and the environment. It is not possible to predict climate change with absolute certainty in any specific case. As such, all data must be considered in light of this uncertainty.

One of the primary challenges in quantifying the impacts of climate change lies in the uncertainty of General Circulation Model projections. The use of multiple General Circulation Models in future climate projection studies is considered to be a good practice. Using different models under the same greenhouse gas scenarios helps evaluate uncertainty, although a thorough assessment of uncertainty necessitates taking into account various greenhouse gas scenarios.

There is no established method to determine which models best stimulate the future accurately. However, various methods exist to address the uncertainty associated with future projections. The ensemble mean projections, such as the 50th percentile, are highlighted in this report as a way to present the findings.

Climate Change Impacts on Health

Climate change can impact human health both directly and indirectly through various exposure pathways. The health effects become more significant as global temperatures rise, precipitation patterns change, and extreme weather events occur more frequently and more intensely [(4)].

Human health is directly impacted by climate change, which can lead to the onset and worsening of non-communicable diseases such as respiratory and cardiovascular illnesses as well as effects on mental health. It also contributes to the harm and loss of life brought on by extreme weather conditions such as wildfires, storms, heat waves, floods, and droughts. Climate change affects health indirectly by altering ecosystems, which can help diseases, pathogens, and contaminants spread to humans. For instance, there are increased risks of food insecurity, increased water and air pollution due to rising temperatures, and the spread of vector-borne diseases into new geographical areas [(4)]. Canada has experienced a documented increase in temperatures and changes in precipitation due to climate change. Increased temperatures have led to favorable conditions for the survival and reproduction of ticks and ticks-borne pathogens [(5)].

Some populations are more affected by the consequences of climate change, with Canadians already witnessing its impact on their health. Health Canada highlights specific groups that are particularly vulnerable, including seniors, individuals with chronic diseases or weakened immune systems, infants and young children, pregnant women, individuals facing social or economic disadvantages such as low-income or housing insecurity, Indigenous Peoples, and residents of remote communities. Table 5 further demonstrates the health impacts from climate change, along with the populations at risk due to these impacts.

Table 5: Climate Change related Health Impacts

Health hazard examples	Health outcome indicator examples	Vulnerable populations
Extreme Heat and Cold	• Heat related morbidity and mortality, such as heat stroke, heat exhaustion, heat cramps,	Elderly individuals, infants and young children, outdoor workers, physically active people, and those with heart diseases may face an

	heat edema, heat rash, heat fainting • Cold-related morbidity and mortality such as frostbite, hypothermia, windburn	increased vulnerability to extreme temperatures
Extreme weather events	• Morbidity and mortality from injuries, illnesses, and mental health outcomes from violent storms, floods and ice	People with lack of adequate housing and/or insurance coverage may face increased susceptibility to extreme weather events, leading to increased rates of illnesses and deaths
Vector-borne diseases	• West Nile Virus • Lyme disease • Other vector borne diseases	People who work outdoors or people who are homeless may be at greater risk for exposure
Food- and water-borne illnesses	• Incidences of illnesses or outbreaks from pathogens in water due to flooding and storm events, and pathogens in food due to higher temperatures, driving growth and survival of pathogens	Pregnant women and children are more at risk of food-and water-borne disease outcomes. Minority linguistic communities may encounter limited accessibility to alerts related to outbreaks associated with food and water
Air quality	• Cardiovascular and respiratory health effects from exposure to aeroallergens or degraded air quality, including ground-level	Individuals with pre-existing physical health conditions, such as asthma, heart diseases may face increased vulnerability to respiratory outcomes

	ozone and particulate matter	
UV radiation	• Sunburns, skin damage leading to wrinkling, increased risk of skin and eye cancers, DNA damage, weakened immune system response, cell atrophy, and development of cataracts	Infants and children have vulnerable skin and eyes that make them highly susceptible to long-term UVR exposure, people who work outdoors or individuals engaged in physical activities outdoors may experience higher UVR exposure, increasing the risk of adverse health effects

Source: Health Canada

Temperature Indices

All temperature indices are expected to have significant warming in the study area under a number of different scenarios, including SSP1-2.6, SSP2-4.5, and SSP5-8.5. The minimum, average, and maximum monthly temperatures are all predicted to rise, making this warming trend more obvious. Additionally, there will be more days with extreme heat, while there will be fewer days with extreme cold, according to predictions.

The overall patterns in temperature shifts can be beneficial to understand the potential spread of vector-borne diseases (such as West Nile virus transmitted by mosquitoes), zoonotic diseases (such as water contamination by E. coli bacteria or harmful algal blooms), and health issues associated with related illnesses and deaths. The direct impacts on health can include non-communicable diseases (such as, respiratory and cardiovascular diseases, mental health impacts), and injuries and deaths resulting from extreme weather events [(4)]. High temperatures affect human health and give rise to a range of adverse effects, including heat rash, heat cramps, dehydration, heat fainting, exhaustion, and ultimately, heat stroke [(6)]. Heatwave events can particularly have severe impact on vulnerable groups such as the elderly, infants, and people with pre-existing medical conditions. They face a higher risk of mortality and illness due to heat exposure compared to the general population [(7)].

Seasonal Mean Temperatures

Seasonal baseline mean temperatures for Oxford County are: -4.4, 6.8, 19.9 and 9.8°C for winter, spring, summer, and fall respectively (Table 6). This gives a year-round average temperature of 8.1°C for 1986-2014.

Table 6: Baseline and Projected Mean Temperatures for Oxford County (°C) by Season, SSP1-2.6, SSP2-4.5, and SSP5-8.5

Mean Temperatures (°C)	Baseline 1986 -2014	2050s			2080s		
		SSP1-2.6	SSP2-4.5	SSP5-8.5	SSP1-2.6	SSP2-4.5	SSP5-8.5
Winter	-4.4°C	-1.8°C	-1.4°C	-0.4°C	-1.6°C	-0.1°C	2.1°C
Spring	6.8°C	8.8°C	9.1°C	9.8°C	9.0°C	10.0°C	12.1°C
Summer	19.9°C	21.8°C	22.3°C	23.0°C	22.0°C	23.2°C	25.7°C

Fall	9.8°C	11.7°C	12.1°C	12.9°C	11.9°C	13.0°C	15.4°C
Annual	8.1°C	10.2°C	10.6°C	11.4°C	10.3°C	11.5°C	13.8°C

Seasonal baseline mean temperatures for Elgin County and the City of St. Thomas are: -3.5, 7.3, 20.3, and 10.5°C for winter, spring, summer, and fall respectively (Table 7) This gives a year-round average temperature of 8.7°C for 1986-2014. In general, the average temperatures in Elgin County and the City of St. Thomas tend to be slightly higher as compared to Oxford County.

Table 7: Baseline and Projected Mean Temperatures for Elgin County and the City of St. Thomas (℃) by Season - SSP1-2.6, SSP2-4.5, and SSP5-8.5

Mean Temperatures (°C)	Baseline 1986 - 2014	2050s			2080s		
		SSP1-2.6	SSP2-4.5	SSP5-8.5	SSP1-2.6	SSP2-4.5	SSP5-8.5
Winter	-3.5°C	-1.0°C	-0.6°C	0.5°C	-0.8°C	0.7°C	2.8°C
Spring	7.3°C	9.3°C	9.6°C	10.3°C	9.5°C	10.5°C	12.5°C
Summer	20.3°C	22.1°C	22.6°C	23.3°C	22.3°C	23.5°C	26.0°C
Fall	10.5°C	12.4°C	12.8°C	13.6°C	12.6°C	13.7°C	16.1°C
Annual	8.7°C	10.3°C	11.2°C	12.0°C	10.9°C	12.1°C	14.3°C

Maximum and Minimum Temperatures

High temperatures can significantly influence various health consequences, including heat-related illnesses and cold-related injuries. Prolonged exposure to excessive heat can cause dehydration, heat exhaustion, heat stroke, heat edema, reduced coordination, fatigue, nausea and worsen respiratory illnesses [(8)]. Moreover, extreme temperatures are associated with deteriorating mental health and an upsurge in violent incidents. On the other hand, extreme cold can result in frostbite, hypothermia, and the potential aggravation of pre-existing medical conditions. Certain individuals are more susceptible to frostbite and hypothermia in cold weather conditions compared to others. These high-risk groups include homeless people, outdoor workers, individuals living in poorly insulated homes, people with certain medical conditions such as diabetes, peripheral neuropathy, and diseases affecting blood vessels, infants, and older adults [(9)]. Additionally, rapid freezing and winter storms can create hazardous travel conditions, leading to increased illness and death [(10)]. The baseline and projected minimum and maximum temperatures for each season categorized by SSP1-2.6, SSP2-4.5, and SSP5-8.5 in Oxford County and Elgin County and the City of St. Thomas are listed below.

The 1986-2014 baseline annual average minimum temperatures for Oxford County (Table 8) and Elgin County and the City of St. Thomas (Table 9) were recorded at 3.2°C and 3.9°C respectively. For both regions, projections show a significant increase in minimum seasonal temperatures. It is anticipated that minimum temperatures in these regions will rise by roughly 5.0°C to 5.5°C during different seasons by the 2080s.

Furthermore, it is anticipated that by the 2080s, both Oxford and Elgin County and the City of St. Thomas will experience a minimum of 19.6°C to above 20°C in the summer season under the SSP5-8.5 emissions scenario. In this report, the tropical night refers to the number of days where the lowest temperature during nighttime remains above 20°C. Inadequate nighttime cooling can intensify the stress of hot summer days and heatwaves. The presence of tropical nights can add to the challenge of allowing the body to effectively cool down. This is a serious health risk, especially to the vulnerable populations such as the elderly, homeless individuals, and those residing in residences lacking air conditioning. Their risks increase particularly if these heat events persist for more than a few days. By the 2080s under SSP5-8.5, it is anticipated that minimum temperatures during the winter months will approach 0°C. This change may lead to a rise in the frequency of freeze-thaw cycles, potentially resulting in overland flooding caused by the melting of snow and the formation of ice jams in waterways.

Table 8: Baseline and Projected Average Seasonal Minimum Temperatures for Oxford County – SSP1-2.6, SSP2-4.5, and SSP5-8.5

Seasonal Minimum Temperatures (°C)	Baseline 1986 - 2014	2050s			2080s		
		SSP1-2.6	SSP2-4.5	SSP5-8.5	SSP1-2.6	SSP2-4.5	SSP5-8.5
Winter	-7.9°C	-5.0°C	-4.5°C	-3.3°C	-4.8°C	-3.1°C	-0.7°C
Spring	1.7°C	3.6°C	3.9°C	4.6°C	3.7°C	4.7°C	6.8°C
Summer	14.1°C	15.8°C	16.3°C	17.1°C	16.0°C	17.2°C	19.6°C
Fall	5.1°C	6.8°C	7.3°C	8.1°C	7.0°C	8.2°C	10.6°C
Annual	3.2°C	5.3°C	5.8°C	6.6°C	5.5°C	6.7°C	9.0°C

Table 9: Baseline and Projected Average Seasonal Minimum Temperatures for Elgin County and the City of St. Thomas – SSP1-2.6, SSP2-4.5, and SSP5-8.5

Seasonal Minimum Temperatures (°C)	Baseline 1986 - 2014	2050s			2080s		
		SSP1-2.6	SSP2-4.5	SSP5-8.5	SSP1-2.6	SSP2-4.5	SSP5-8.5
Winter	-7.1°C	-4.3°C	-3.8°C	-2.7°C	-4.1°C	-2.4°C	-0.1°C
Spring	2.3°C	4.1°C	4.5°C	5.1°C	4.3°C	5.3°C	7.3°C
Summer	14.6°C	16.3°C	16.8°C	17.5°C	16.5°C	17.6°C	20.1°C
Fall	5.8°C	7.5°C	7.9°C	8.7°C	7.7°C	8.9°C	11.3°C
Annual	3.9°C	5.9°C	6.4°C	7.2°C	6.1°C	7.3°C	9.6°C

The annual average baseline in seasonal maximum temperatures for Oxford County (Table 10) and Elgin County and the City of St. Thomas (Table 11) was 12.9 and 13.4°C respectively. Both the regions are projected to encounter an increase in their maximum temperatures. The average maximum temperatures during summers are anticipated to surpass 30°C for both areas under SSP5-8.5 emissions scenario. Likewise, the average maximum temperatures during winters will also increase ranging between 4.2 to 5.7°C by the 2080s under SSP5-8.5.

Table 10: Baseline and Projected Average Seasonal Maximum Temperatures for Oxford County – SSP1-2.6, SSP2-4.5, and SSP5-8.5

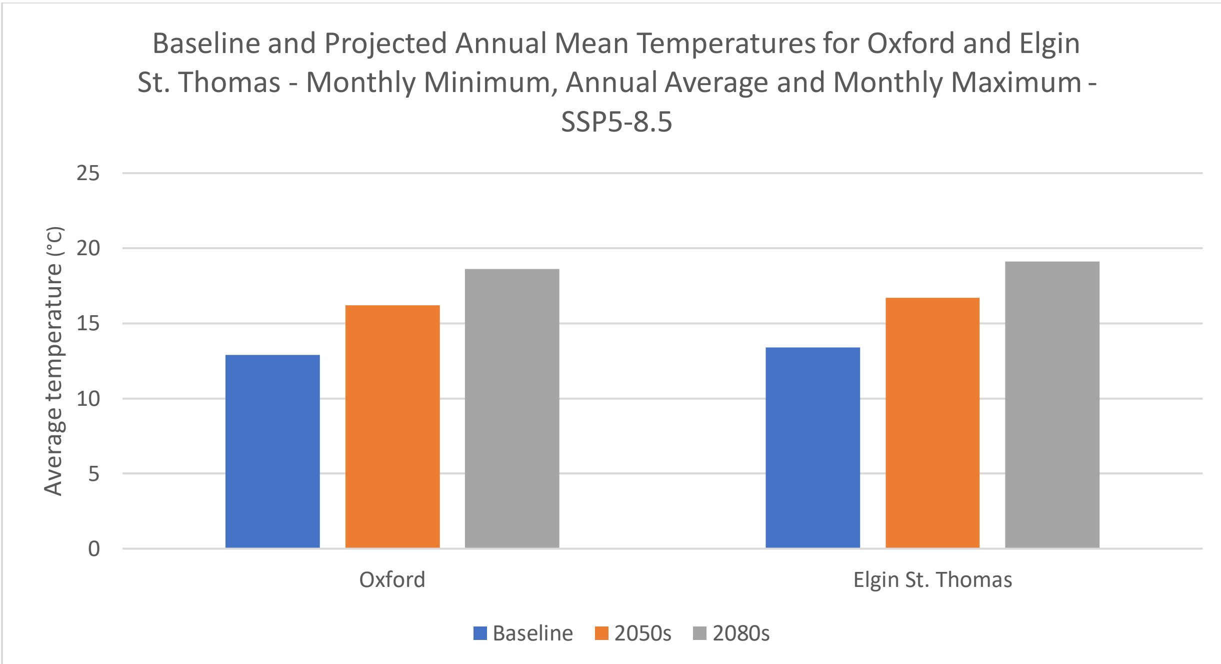
Seasonal Maximum Temperatures (°C)	Baseline 1986 - 2014	2050s			2080s		
		SSP1-2.6	SSP2-4.5	SSP5-8.5	SSP1-2.6	SSP2-4.5	SSP5-8.5
Winter	-0.8°C	1.3°C	1.7°C	2.7°C	1.6°C	2.9°C	5.0°C
Spring	11.8°C	13.9°C	14.3°C	15.0°C	14.2°C	15.2°C	17.3°C
Summer	25.8°C	27.7°C	28.3°C	29.0°C	28.0°C	29.2°C	31.7°C
Fall	14.6°C	16.6°C	17.0°C	17.7°C	16.7°C	17.8°C	20.3°C
Annual	12.9°C	15.0°C	15.4°C	16.2°C	15.2°C	16.3°C	18.6°C

Table 11: Baseline and Projected Average Seasonal Maximum Temperatures for Elgin County and the City of St. Thomas – SSP1-2.6, SSP2-4.5, and SSP5-8.5

Seasonal Maximum Temperatures (°C)	Baseline 1986 - 2014	2050s			2080s		
		SSP1-2.6	SSP2-4.5	SSP5-8.5	SSP1-2.6	SSP2-4.5	SSP5-8.5
Winter	0.1°C	2.3°C	2.6°C	3.6°C	2.5°C	3.7°C	5.8°C
Spring	12.3°C	14.4°C	14.8°C	15.5°C	14.7°C	15.7°C	17.7°C
Summer	25.9°C	27.9°C	28.4°C	29.1°C	28.1°C	29.3°C	31.8°C
Fall	15.3°C	17.3°C	17.7°C	18.4°C	17.4°C	18.5°C	21.0°C
Annual	13.4°C	15.6°C	16.0°C	16.7°C	15.7°C	16.8°C	19.1°C

The projected increase in mean temperatures for Oxford County, as illustrated in Figure 3 and for Elgin St. Thomas (Figure 4) for the annual values under the SSP5-8.5 scenario, are also expected to increase for minimum and maximum temperatures.

Figure 3: Baseline and Projected Annual Mean Temperatures for Oxford County and Elgin County and the City of St. Thomas – Monthly Minimum, Annual Average, and Monthly Maximum – SSP5-8.5



Extreme Heat Days and Tropical Nights

A heat warning advisory is issued when notifications are received from Environment and Climate Change Canada's meteorological services when an impending heat event is forecasted for the Southwestern Public Health (SWPH) region. Based on the anticipated duration and intensity of the conditions, SWPH will issue either a Heat Warning or an Extended Heat Warning:

- Heat Warning: This is declared when the forecasted temperatures are expected to reach a minimum of 31°C, with overnight temperatures reaching or exceeding 20°C for two consecutive days, or when the Humidex is forecasted to be at least 40°C for two consecutive days.
- Extended Heat Warning: In the case where forecasted temperatures are anticipated to reach a minimum of 31°C, with overnight temperatures exceeding 20°C for three or more consecutive days, or when the Humidex is at least 40°C for three or more consecutive days, an Extended Heat Warning is issued.

The ClimateData.ca portal provides information on the number of days where the daily maximum temperature is greater than 30°C and 32°C, but it does not provide details for 31°C. Therefore, the inclusion of days with maximum temperatures above 30°C and 32°C in the report intends to highlight the impact of extreme heat within the local region, both at the present time and in projections for the future.

Based on the SSP5-8.5 scenario, it is expected that by the 2080s Oxford and Elgin County and the City of St. Thomas will experience a significant rise in the number of days surpassing 30°C. As indicated in Table 12, Oxford County will have 80 days, which is 69 days more than the baseline of 11 days. Similarly, Elgin County and the City of St. Thomas is expected to encounter 78 such days, surpassing the baseline of 8 days by 70 days. This highlights that the annual days above 30°C by the 2080s will experience a significant rise when compared with baseline scenarios.

Table 12 : Baseline and Projected Annual Days above 30°C for Oxford County and Elgin County and the City of St. Thomas – SSP1-2.6, SSP2-4.5, and SSP5-8.5

Annual Days above 30°C[a]	Baseline 1986 -2014	2050s			2080s		
		SSP1-2.6	SSP2-4.5	SSP5-8.5	SSP1-2.6	SSP2-4.5	SSP5-8.5
Oxford County	11	30	37	45	32	48	80
Elgin County and the City of St. Thomas	8	25	33	41	27	45	78

[a]*Data sourced from Climate Data Canada*

The frequency of days with maximum temperatures exceeding 32°C is also expected to increase in the future as illustrated in Table 13. According to the SSP5-8.5 scenario, Oxford County will have 55 annual days with such temperatures, which is 52 more days than the baseline of 3 days. Similarly, Elgin County and the City of St. Thomas will have 51 days surpassing 32°C, which is 49 days more than the baseline of 2 days. These findings emphasize the importance of readiness and preparedness in the study region, as it needs to adapt to a future where days surpassing 32°C will become increasingly normal during summer.

Table 13: Baseline and Projected Annual Days above 32°C for Oxford County and Elgin County and the City of St. Thomas – SSP1-2.6, SSP2-4.5, and SSP5-8.5

Annual Days above 32°C[b]	Baseline 1986 -2014	2050s			2080s		
		SSP1-2.6	SSP2-4.5	SSP5-8.5	SSP1-2.6	SSP2-4.5	SSP5-8.5
Oxford County	3	12	16	22	13	24	55
Elgin County and the City of St. Thomas	2	9	12	17	9	20	51

[b]*Data sourced from [Climate Data Canada]()*

It is crucial to prepare for situations where people in local areas could endure prolonged periods of high temperatures, especially during heatwaves characterized by Tropical Nights—when the minimum daily temperature stays above 20°C.The baseline period of 1986-2014, the average number of Tropical Nights in Oxford County was recorded at 5 days, whereas Elgin County and the City of St. Thomas experienced an average of 8 days. According to the projections of SSP5-8.5, both regions will experience a significant increase in Tropical Nights by the 2080s. Oxford County will have 55 Tropical Nights, which is an addition of 50 days from the baseline. Similarly, Elgin County and the City of St. Thomas will experience 63 Tropical Nights per year, indicating an increase of 55 days as compared to the baseline. These projections as illustrated in Table 14 and Figure 4, indicate that under the SSP5-8.5 emissions scenario, both regions are likely to experience at least one and a half month of Tropical Nights by the 2080s.

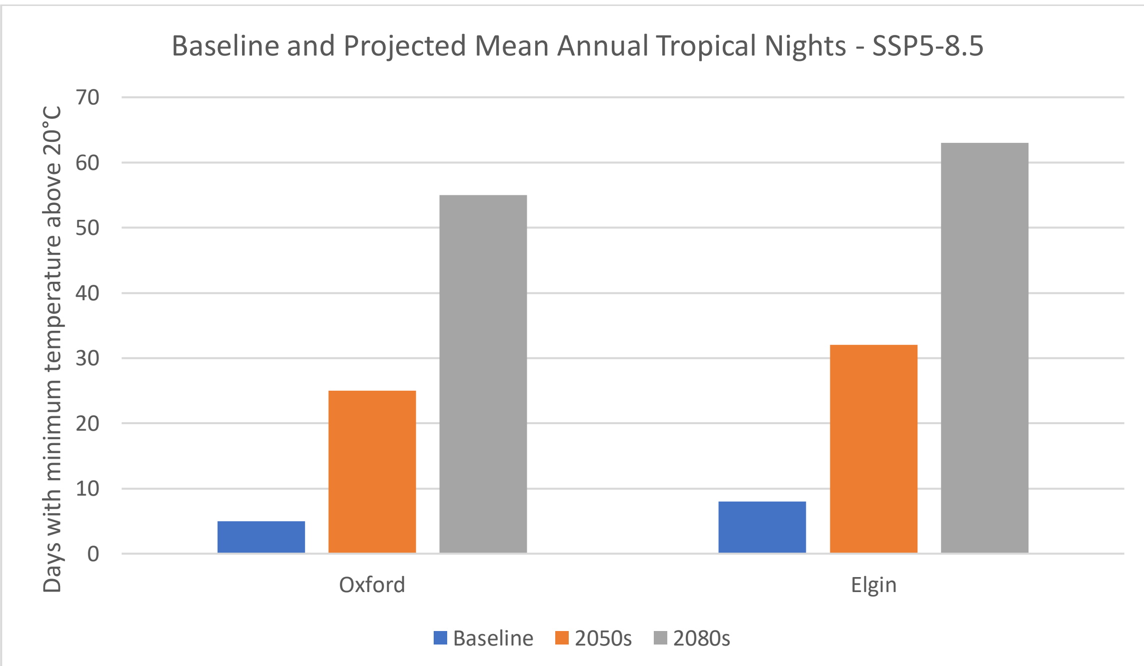
Table 14: Baseline and Projected Annual Mean Tropical Nights for Oxford County and Elgin County and the City of St. Thomas – SSP1-2.6, SSP2-4.5, and SSP5-8.5

Tropical Nights (days)[c]	Baseline 1986 -2014	2050s			2080s		
		SSP1-2.6	SSP2-4.5	SSP5-8.5	SSP1-2.6	SSP2-4.5	SSP5-8.5

Oxford County	5	14	19	25	15	26	55
Elgin County and the City of St. Thomas	8	20	25	32	20	33	63

[c]*Data sourced from [Climate Data Canada]*

Figure 4: Projected Annual Mean Tropical Nights for Oxford County and Elgin County and the City of St. Thomas – SSP5- 8.5

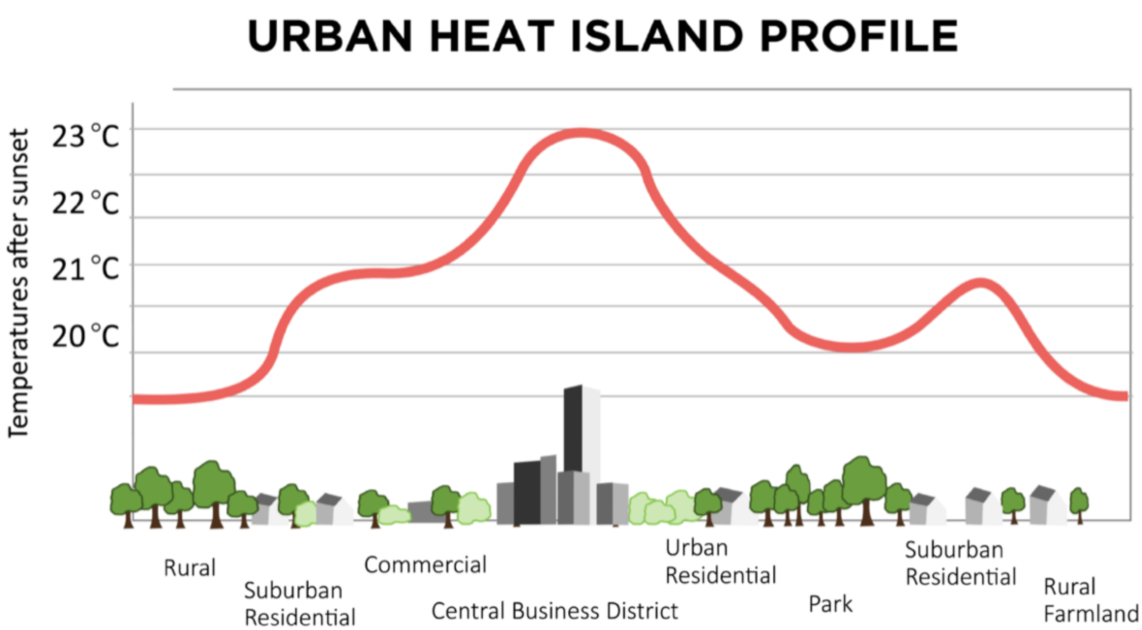


Urban vs. Rural Temperatures

Temperature variations can significantly be influenced by the urban heat island (UHI) effect. Urban and rural lands have different thermal and radiative properties, which leads to UHI. In urban settings, surfaces constructed with materials like roofs, paved roads, and parking lots etc. have lower albedo (i.e., less reflectivity, resulting in higher temperatures) and can capture significant amounts of solar heat, leading to elevated surface and air temperatures [(11)]. The higher air temperatures found in urban areas, particularly at night, can hinder the body's natural cooling process, escalating the health risks linked to extreme heat events. It increases air pollution levels, exacerbate daytime temperatures, and hinder the nighttime cooling effect. These factors consequently contribute to an increase in heat-related illnesses and deaths, including general discomfort, respiratory issues, heat exhaustion, heat cramps, and heat stroke [12]. UHI also has an effect on the thermal conditions inside of buildings, which include factors such as air temperature, humidity, and air flow. This is especially noticeable in buildings without mechanical ventilation and air conditioners [13].

The lack of vegetation in cities also reduces transpiration and, as a result, the cooling effect it produces. In addition, the high proportion of impervious surfaces in urban areas makes it easier for water to drain quickly through sewage systems, which minimizes heat loss through evaporation. The temperature variations among different developmental areas are illustrated in Figure 5 [14].

Figure 5: Urban Heat Island Profile



Seasonal variations in urban heat islands can be attributed to factors such as changes in solar intensity, ground cover, and weather. As a result, these heat islands usually become more noticeable in the summer. Table 15 shows the average annual maximum temperatures for three urban municipalities and three rural municipalities to represent the contrasting daytime temperatures anticipated between urban and rural areas within the study region. The major urban municipalities in Oxford County are Ingersoll, Tillsonburg, and Woodstock. Three additional smaller municipalities (characterized by a lower degree of urbanization and a more rural nature) have been randomly chosen: the Township of East Zorra-Tavistock, the Township of Blandford-Blenheim, and the Township of Zorra.

Table 15 shows that the average annual maximum temperature in the study area is about 0.5°C higher in the urban municipalities than it is in the smaller rural municipalities. However, there are exceptions as well, like the Township of Blandford-Blenheim where the temperature trends are similar to the urban municipalities.

Table 15: Annual Maximum Temperatures for Urban vs. Rural Municipalities in Oxford County - SSP5-8.5

Urban vs. Rural	Municipality	Population Size[2]	Historical (2014)	2050	2080[3]
Urban	Ingersoll	13,693	13.5°C	16.1°C	18.0°C
	Tillsonburg	18,615	13.9°C	16.5°C	18.3°C
	Woodstock	46,705	13.4°C	16.0°C	18.0°C
Rural	East Zorra-Tavistock	7,841	13.2°C	15.8°C	17.7°C
	Blandford-Blenheim	7,565	13.5°C	16.0°C	18.0°C
	Zorra	8,628	13.3°C	15.9°C	17.8°C

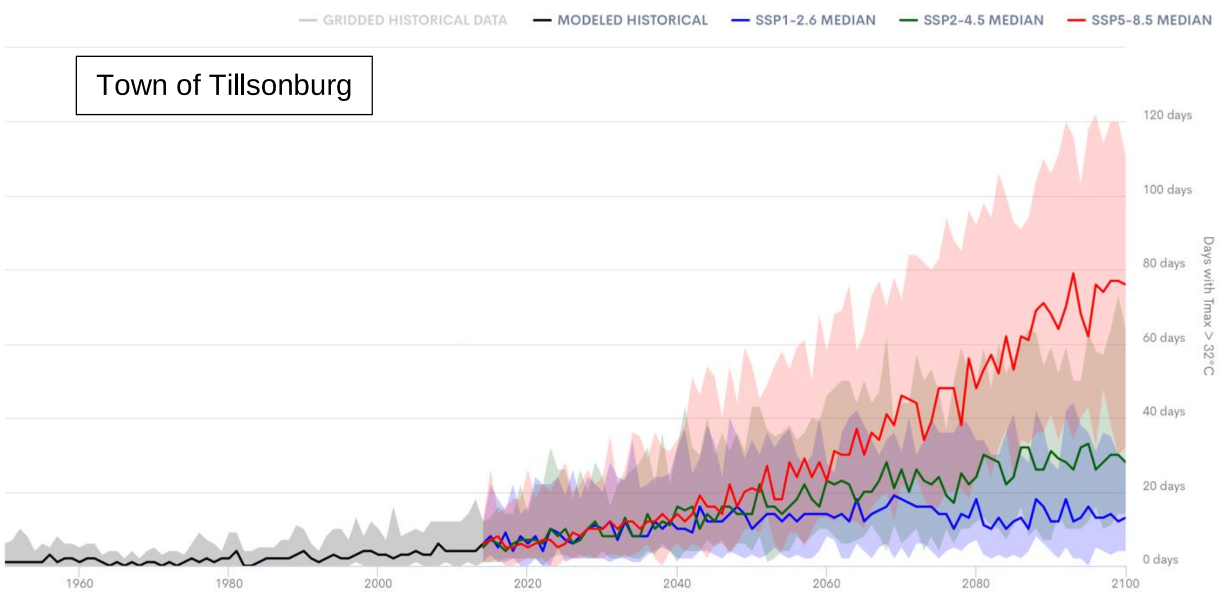
Additionally, larger temperature differences between urban and rural areas have been seen in other temperature variables. For instance, differences between urban and rural municipalities can be up to 6 days when it comes to extreme temperature like the average annual number of days exceeding 32°C. Table 16 and Figure 6 provide more information on these results.

[2] Source: Population statistics collected from Oxford County Community Profile and Statistics, 2021
[3] Data collected from Climate Data Canada

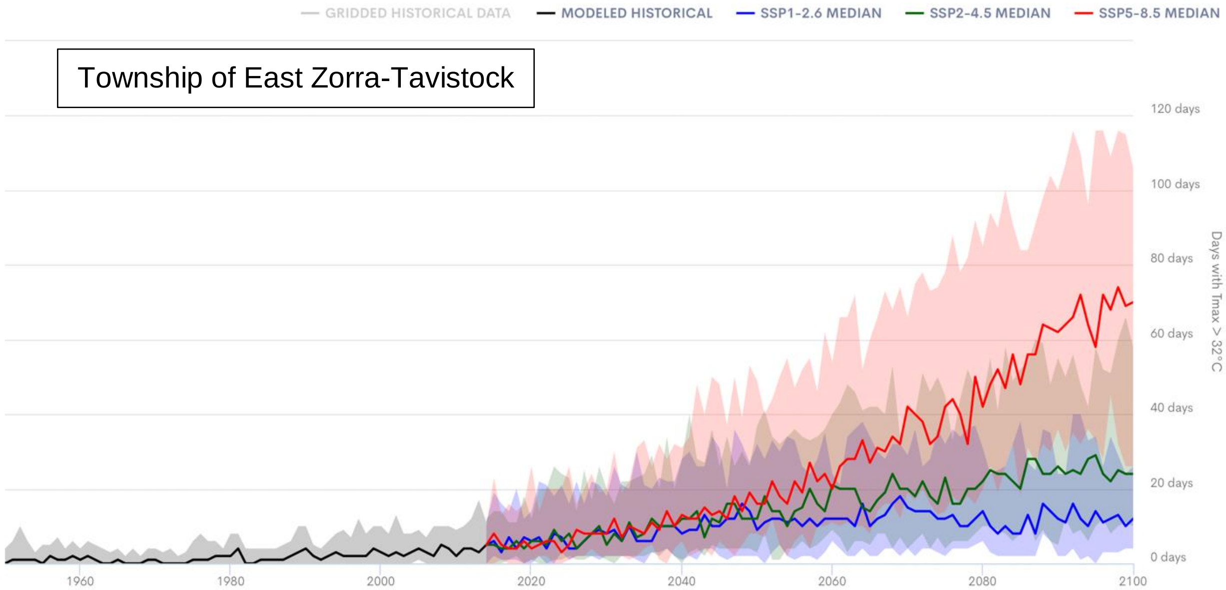
Table 16: Days Above 32°C for Urban vs. Rural Municipalities - SSP5-8.5

Urban vs Rural[4]	Municipality	Population size	Historical (2014)	2050	2080[5]
Urban	Ingersoll	13,693	5	18	45
	Tillsonburg	18,615	6	21	48
	Woodstock	46,705	5	18	45
Rural	East Zorra-Tavistock	7,841	5	16	42
	Blandford-Blenheim	7,565	5	18	46
	Zorra	8,628	4	18	44

Figure 6: Days with TMax >32°C for City of Woodstock and Township of East Zorra-Tavistock – SSP1-2.6, SSP2-4.5, and SSP5-8.5



[4] Source: Urban and rural areas information sourced from [Oxford County]
[5] Data collected from [Climate Data Canada]



Source: [Climate Change Data]

Dehydration, fatigue, and inability to sweat or the body's ability to cool itself are just a few physiological stresses that can arise from prolonged or excessive exposure to high temperatures. Heat-related illnesses can range from heat rashes and cramps to more severe conditions such as heat stroke. In addition, extreme heat can worsen pre-existing medical conditions like cardiovascular and respiratory diseases, raise the risk of stroke, and make people more vulnerable to infectious diseases [(11)(15)]. Young children, people with chronic illnesses, outdoor workers such as construction workers, people who are physically active, Indigenous Canadians, the marginally housed or homeless, and elderly people who are socially isolated are some groups who are especially vulnerable to these risks [(11)].

However, it is important to recognize that that the urban heat island (UHI) effect is not the only factor contributing to high temperatures in a municipality. The Great Lakes, topography, and geographic location are additional factors that can affect the temperature patterns observed in the municipalities.

Heat Waves

Extended periods of extremely hot weather, frequently with higher humidity, are referred to as heat waves. Heat waves depend on the usual weather conditions in a given area and the typical seasonal temperatures. In a cooler area, a temperature that is normal in a hotter area might be referred to as a heat wave. Understanding local climate changes can help in the development of mitigation strategies to lessen the effect on the population, aligning with local customs and behaviors.

A heat warning will be issued to the public if certain conditions are met, including:

- Two consecutive days with predicted daytime temperature is 31°C or higher and predicted 20°C or higher at night, and/or
- Two consecutive days with predicted humidex is of 40°C or higher

The severe effects of extreme heat are mostly felt by the highly vulnerable groups, such as the elderly, children, people with low incomes, and the homeless. In addition, individuals with pre-existing chronic health conditions such as cardiovascular or respiratory disorders, as well as mental or behavioral health issues, face an elevated risk of heat-related illness. Extreme heat events are more likely to occur as a result of both local environmental changes and global climate change, which coincide with an increasing population at risk from heat-related illnesses. Therefore, it is essential to understand efficient methods for anticipating, managing, and preparing for heat waves (14).

The heat wave analysis tool by Climate Data Canada enables users to input specific thresholds for local heat wave events. This tool creates personalized heat wave event indicators for various geographic regions in Canada. Data on the frequency of heat waves, specifically the total number of heat wave events that took place during a specific year can be generated.

Specific grid cells within Oxford County and Elgin County and the City of St. Thomas were selected for the number of extended heat events exceeding 3 days in those regions. This information is illustrated in Table 17.

Table 17: Baseline and Projected Annual Frequency of Extended Heat Warning Events for Oxford County and Elgin County and the City of St. Thomas – SSP1-2.6, SSP2-4.5, and SSP5-8.5

Heat Wave Frequency	Baseline 1971-2000[6]	2050s			2080s		
		SSP1-2.6	SSP2-4.5	SSP5-8.5	SSP1-2.6	SSP2-4.5	SSP5-8.5
Oxford County	0.21	0.97	1.40	2.33	0.90	2.47	5.40
Elgin County and the City of St. Thomas	0.27	0.98	1.52	2.52	1.03	2.52	5.37

The frequency of extended heat wave events is projected to increase, particularly as time progresses and emissions rise based on the SSP scenario. The health of people living in the study area will be significantly impacted by these extended periods of extreme heat. Heat-related illnesses can develop quickly, have a negative impact on long-term health, and even be fatal. Children, older adults, people working or doing physical activity outdoors are vulnerable groups that are particularly susceptible to the negative effects of prolonged exposure to high temperatures.

Extreme Cold Days, Frost Days, and Ice Days

The occurrence of Extreme Cold Days, Frost Days and Ice Days is declining. An Extreme Cold Day refers to a day with minimum temperatures below -15°C. Across Oxford County and Elgin County and the City of St. Thomas, the total number of Extreme Cold Days is expected to decrease in all three emission scenarios from 2040 till 2099. Table 18 shows that the Extreme Cold Days in Oxford County will decline to 0 day by the 2080s, which is 14 days less than the baseline. Similarly, Elgin County and the City of St. Thomas will have no day in the 2080s under the SSP5-8.5 with minimum temperatures below -15°C. However, while the Extreme Cold Days will become less frequent in the coming years, it remains crucial to adequately prepare for and manage the potential health impacts associated with extreme cold conditions.

[6] The heat wave events for the baseline 1971-2000 have been taken from the Ontario Climate Change and Health Modelling Study report, as it was unavailable in the ClimateData.ca portal.

Table 18: Baseline and Projected Extreme Cold Days (<-15°C) for Oxford County and Elgin County and the City of St. Thomas

Extreme Cold Days (<-15°C)[d]	Baseline 1986-2014	2050s			2080s		
		SSP1-2.6	SSP2-4.5	SSP5-8.5	SSP1-2.6	SSP2-4.5	SSP5-8.5
Oxford County	14	3	3	1	3	0	0
Elgin County and the City of St. Thomas	10	2	1	0	2	0	0

[d]*Data sourced from Climate Data Canada*

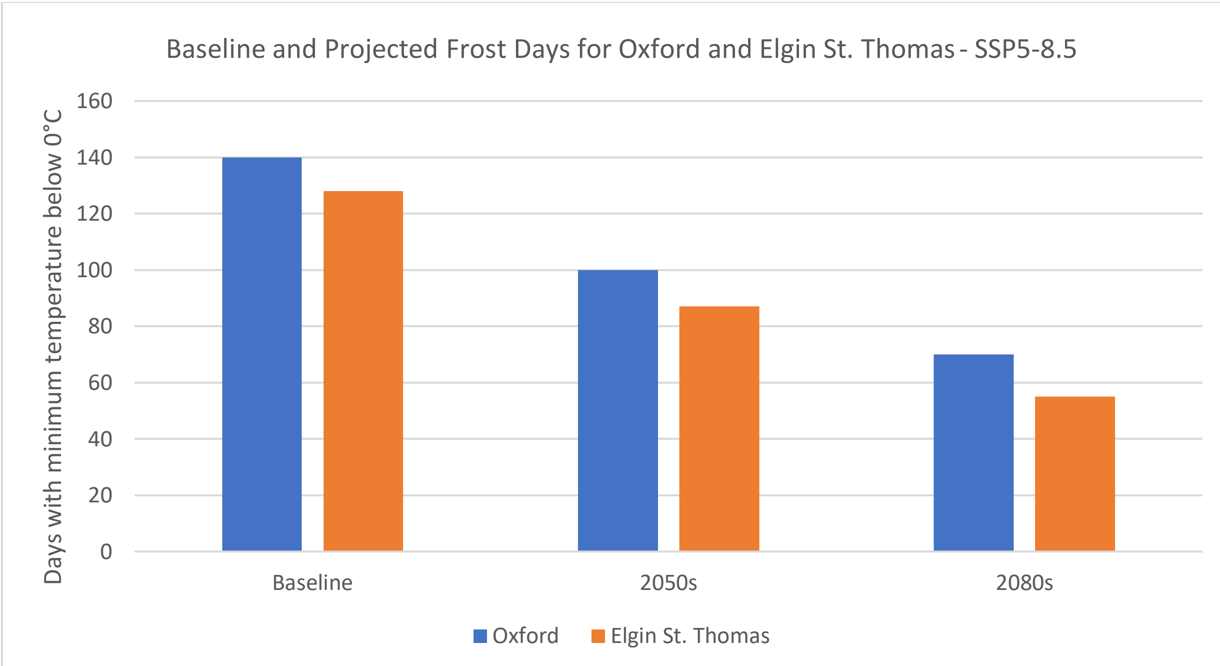
A Frost Day refers to a day where there is a possibility of frost occurring, indicated by a minimum temperature below 0°C. Frost Days are expected to decline by up to 70 days by the 2080s under the SSP5-8.5 scenario in Oxford County according to Table 19 and Figure 7. Similarly, Elgin County and the City of St. Thomas will also experience a decline in Frost Days by 73 days to 55 days, from the baseline of 128 days. Frost and Ice Days help in understanding the patterns of freezing and thawing in each region and the risks involved, such as the likelihood of accidents and injuries brought on by icy conditions, including traffic collisions.

Table 19: Baseline and Projected Frost Days for Oxford County and Elgin County and the City of St. Thomas – SSP1-2.6, SSP2-4.5, and SSP5-8.5

Frost Days[e]	Baseline 1986 -2014	2050s			2080s		
		SSP1-2.6	SSP2-4.5	SSP5-8.5	SSP1-2.6	SSP2-4.5	SSP5-8.5
Oxford County	140	117	110	100	114	98	70
Elgin County and the City of St. Thomas	128	104	97	87	101	85	55

[e]*Data sourced from Climate Data Canada*

Figure 7: ***Baseline and Projected Annual Mean Frost Days for Oxford County and Elgin County and the City of St. Thomas – SSP5-8.5***



According to Table 20 and Figure 8, the study also forecasts a decline in the number of Ice Days. Ice Days refer to the total number of days where the maximum temperature remains below 0°C throughout the day. Since ticks can remain active in temperatures above 4°C, according to Alberta Health (2019), this decline in days with below-freezing temperatures may have an impact on tick survival and spread (16). Warmer winters may extend the period of activity for blacklegged ticks, which can spread the bacteria that causes Lyme disease. Blacklegged ticks are typically most active in the spring and fall seasons (16).

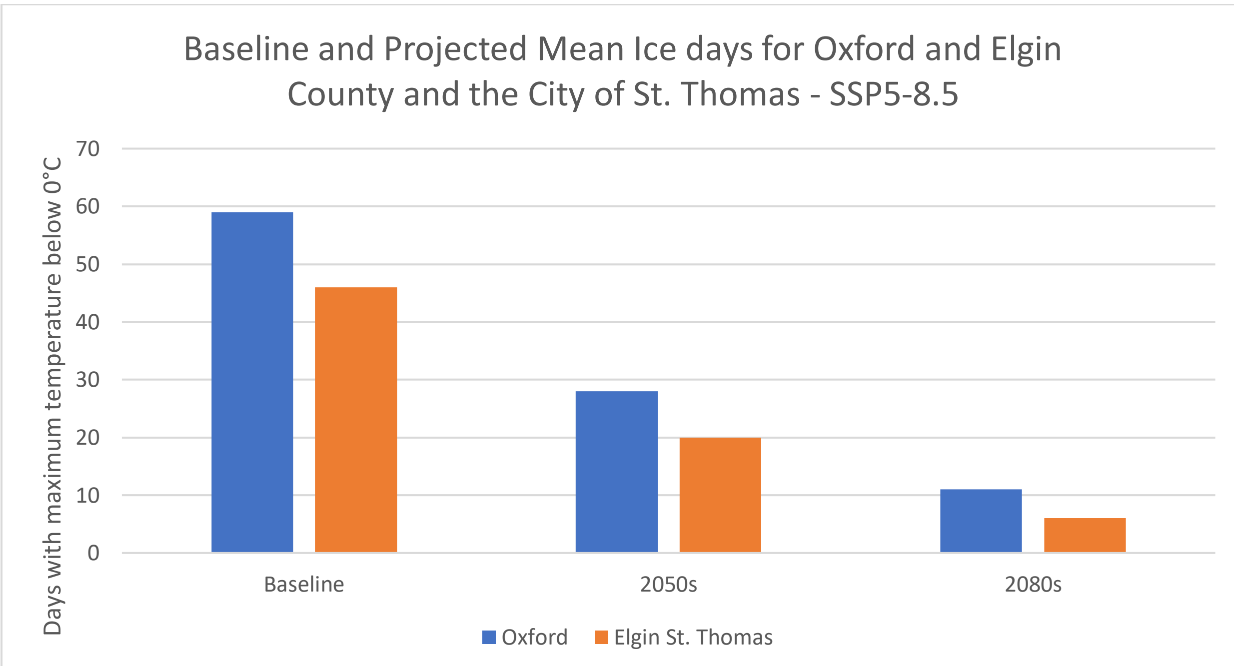
Table 20: Baseline and Projected Ice Days for Oxford County and Elgin County and the City of St. Thomas – SSP1-2.6, SSP2-4.5, and SSP5-8.5

Ice Days[f]	Baseline 1986-2014	2050s			2080s		
		SSP1-2.6	SSP2-4.5	SSP5-8.5	SSP1-2.6	SSP2-4.5	SSP5-8.5
Oxford County	59	39	36	28	37	27	11

Elgin County and the City of St. Thomas	46	29	26	20	28	18	6

[f]*Data sourced from Climate Data Canada*

Figure 8: Baseline and Projected Annual Mean Ice Days for Oxford County and Elgin County and the City of St. Thomas – SSP5-8.5



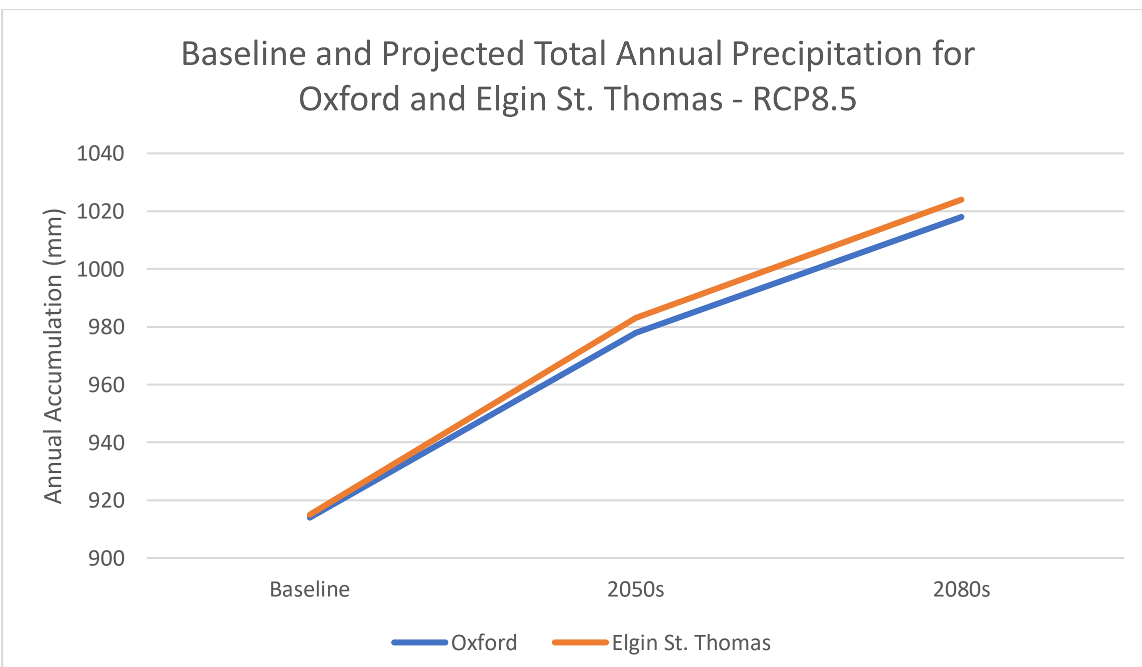
Precipitation indices

This section presents projections for both total precipitation accumulation and extreme precipitation indices.

Total Precipitation

The Total Annual Average Precipitation is expected to experience a slight increase in the coming decades, as illustrated in Figure 9. The changes in precipitation are largely uniform across the study area. By the 2080s, it is anticipated that Oxford County's baseline average of 914 mm will increase to 991 mm (SSP2-4.5) or 1018 mm (SSP5-8.5). Elgin County and the City of St. Thomas' baseline average of 915 mm is predicted to rise to approximately 1000 mm (SSP2-4.5) or 1024 mm (SSP5-8.5) by the 2080s, indicating that both regions will see an increase.

Figure 9: Baseline and Projected Total Annual Precipitation Accumulation for Oxford County and Elgin County and the City of St. Thomas (mm) (SSP5-8.5)

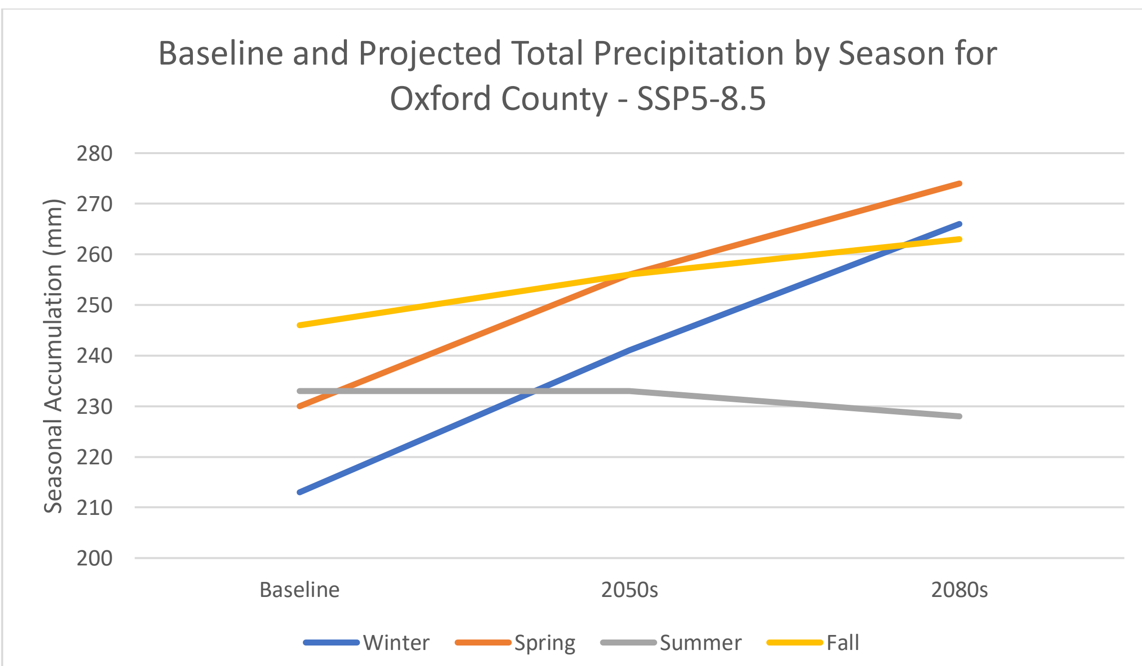


In Oxford County, the projections indicate that by the 2080s, there will be an increase in winter, spring, and fall precipitation accumulations. However, there will be a slight decrease in summer precipitation, although the decrease is not expected to be significant. Table 21 and Figure 10 provide the precipitation accumulation projections for each season in Oxford County based on the SSP1-2.6, SSP2-4.5, and SSP5-8.5 scenarios.

Table 21: Baseline and Projected Total precipitation (mm) by Season for Oxford County – SSP1-2.6, SSP2-4.5, and SSP5-8.5

Total precipitation (mm)	Baseline 1986-2014	Current 2015-2022	2050s			2080s		
			SSP1-2.6	SSP2-4.5	SSP5-8.5	SSP1-2.6	SSP2-4.5	SSP5-8.5
Winter	213	110	230	234	241	232	251	266
Spring	230	132	244	255	256	250	257	274
Summer	233	134	235	234	233	239	235	228
Fall	246	113	257	259	256	253	255	263
Annual	914	490	962	973	978	969	991	1018

Figure 10: Baseline and Projected Total Precipitation (mm) by Season for Oxford County (SSP5-8.5)

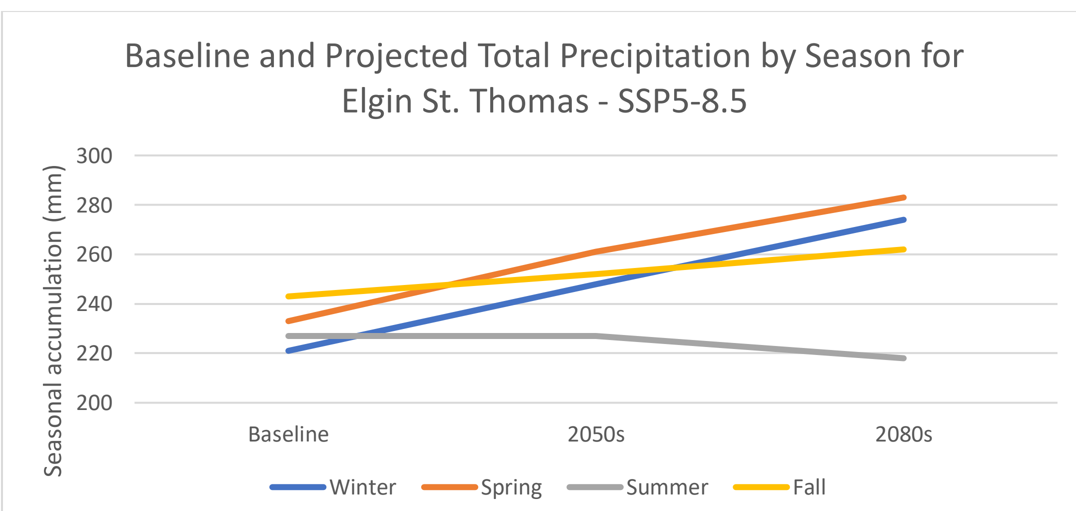


Elgin County and the City of St. Thomas is also expected to have similar seasonal patterns, including higher amounts of rainfall and snowfall in winter, spring, and fall. According to the SSP5-8.5 emissions scenario, winter season will experience most significant increase in precipitation, with an expected rise from 221mm to 274mm by the year 2080. However, in summer it is expected that there will be a slight decline in precipitation from baseline of 227mm to 218mm by the year 2080 under SSP5-8.5 scenario. Table 22 and Figure 11 illustrate the anticipated changes in precipitation accumulation in Elgin County and the City of St. Thomas across various seasons under the SSP1-2.6, SSP2-4.5, and SSP5-8.5 scenarios. There are noticeable variations in particular seasons, even though the annual precipitation as a whole is relatively stable in comparison to the baseline. Precipitation levels are predicted to be higher in the winter, spring and fall while possibly declining slightly in the summer. These changes in seasonal precipitation contribute to the overall changes observed without substantial deviations from the baseline.

Table 22: Baseline and Projected Total Precipitation (mm) by Season for Elgin County and the City of St. Thomas – SSP1-2.6, SSP2-4.5, and SSP5-8.5

Total precipitation (mm)	Baseline 1986-2014	2050s			2080s		
		SSP1-2.6	SSP2-4.5	SSP5-8.5	SSP1-2.6	SSP2-4.5	SSP5-8.5
Winter	221	238	242	248	239	259	274
Spring	234	251	260	261	256	263	283
Summer	227	229	225	227	232	229	218
Fall	243	253	254	252	251	253	262
Annual	915	971	976	983	975	1000	1024

Figure 11: Baseline and Projected Total Precipitation (mm) by Season for Elgin County and the City of St. Thomas (SSP5-8.5)



Dry Spells

The number of days in a row with daily precipitation of less than 1mm refers to the lengthiest dry spells in a year. Higher values indicate longer dry periods. According to the projected data, the anticipated longest dry period for the study area will not change significantly. In the 2050s and 2080s, Table 23 shows marginal increases of one day in the longest dry period.

Table 23: Longest Dry Period in a Year (days) for Oxford County and Elgin County and the City of St. Thomas – SSP1-2.6, SSP2-4.5, and SSP5-8.5

Longest Dry Period in a year (Days)	Baseline 1986-2014	2050s			2080s		
		SSP1-2.6	SSP2-4.5	SSP5-8.5	SSP1-2.6	SSP2-4.5	SSP5-8.5
Oxford County	12	11	11	11	11	11	11
Elgin County and the City of St. Thomas	14	14	14	15	14	14	15

Extreme Precipitation

This section provides the forecasts for multiple indices related to extreme precipitation events. The Maximum One-Day and Five-Day precipitation indices measure the amount of rain or snowfall that occurs within a single day or consecutive days. Maximum 1-Day Total Precipitation refers to the highest volume of precipitation events recorded within a single day during the specified timeframe. This index is commonly known as the day with the highest precipitation, often referred to as the wettest day of the year. Maximum 5-Day Precipitation refers to the highest quantity of precipitation accumulated over a span of five consecutive days in a specified time period. Very Wet Days, or Wet Days >=10mm refers to the number of days within the chosen time frame in which the cumulative precipitation, including both rain and snow, reaches or exceeds 10 mm. The number of days during the specified time period when the total precipitation, including both rain and snow, equals or exceeds 20 mm is represented by Extremely Wet Days or Wet Days >=20mm.

The baseline and predicted changes in the Maximum One-Day and Five-Day Precipitation Accumulations, Very Wet Days and Extremely Wet Days for the study region are shown in Tables 24 and 25.

Table 24: Baseline and Projected Extreme Precipitation Indices for Oxford County – SSP1-2.6, SSP2-4.5, and SSP5-8.5

Region	Index	Baseline 1986 - 2014	2050s			2080s		
			SSP1-2.6	SSP2-4.5	SSP5-8.5	SSP1-2.6	SSP2-4.5	SSP5-8.5
Oxford County	Maximum One-Day Accumulations (mm)	41.1	44.3	44.8	45.2	43.4	46.9	49.4
	Maximum Five-Day Accumulations (mm)	69.6	75.2	76.1	75.9	74.5	76.7	83.5
	Very Wet Days (days)	28	30	31	31	30	31	33
	Extremely Wet Days (days)	8	8	9	9	9	9	11

Table 25: Baseline and Projected Extreme Precipitation Indices for Elgin County and the City of St. Thomas – SSP1-2.6, SSP2-4.5, and SSP5-8.5

Region	Index	Baseline 1986 - 2014	2050s			2080s		
			SSP1-2.6	SSP2-4.5	SSP5-8.5	SSP1-2.6	SSP2-4.5	SSP5-8.5
Elgin County and the City of St. Thomas	Maximum One-Day Accumulations (mm)	40.6	43.3	44.6	44.6	43.1	46.3	49.4
	Maximum Five-Day Accumulations (mm)	71.3	75.7	77.9	77.0	75.7	77.7	84.2
	Very Wet Days (days)	28	30	30	30	30	31	33
	Extremely Wet Days (days)	8	9	9	10	9	10	11

In both regions, the projections indicate that there will be an increase in Very Wet Days and Extreme Wet Days by the 2050s and 2080s under SSP1-2.6, SSP2-4.5, and SSP5-8.5 scenarios. This implies that a higher proportion of precipitation will occur during extreme weather events. Furthermore, the Maximum One-Day and Five-Day events are anticipated to increase in both areas, with the most significant rise expected in Five-Day events. To illustrate, in Oxford County, the projected increase in Maximum Five-Day events is from a baseline of 69.6 mm to 76.1mm by the 2050s and 83.5 mm by the 2080s for SSP5-8.5. Elgin County and the City of St. Thomas is also anticipated to experience an increase in the Maximum Five-Day events from a baseline of 71.3 mm to 77mm in the 2050s and 84.2 mm in the 2080s.

Figures 12 and 13 show visual representations of the changes in the extreme precipitation indices mentioned above for Oxford County. Figure 14 shows the baseline and projected Very Wet Days for Oxford County and Elgin County and the City of St. Thomas under the SSP5-8.5 emissions scenario.

Figure 12: Baseline and Projected Maximum 1-Day Precipitation Accumulation (mm) for Oxford County

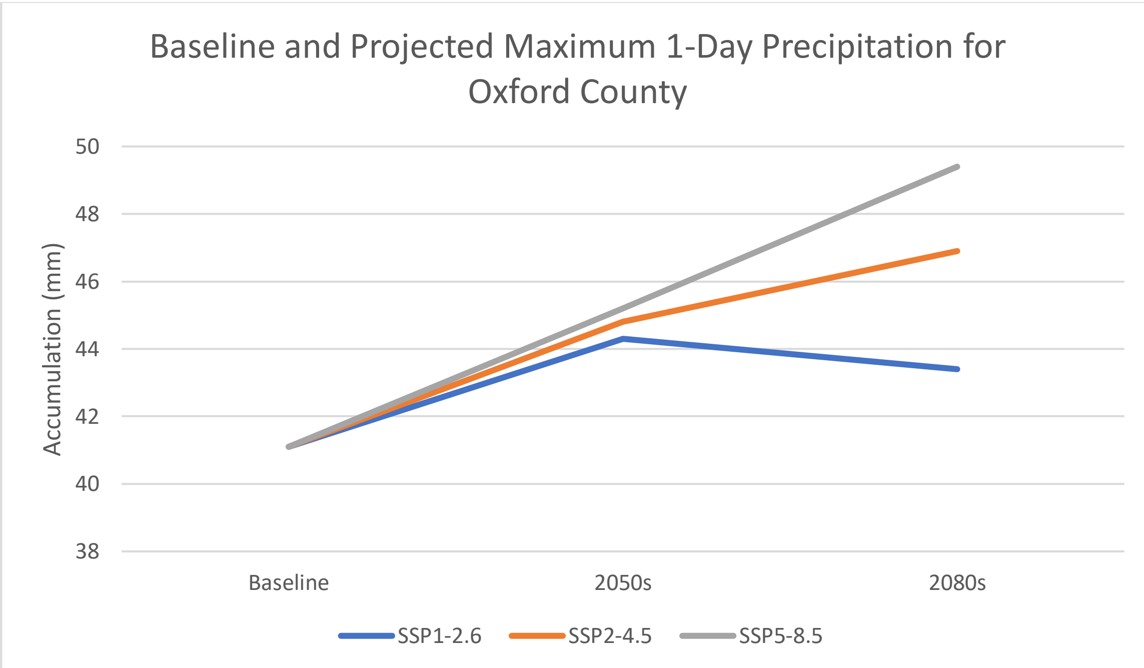


Figure 13: Baseline and Projected Maximum 5-Day Precipitation Accumulation (mm) for Oxford County

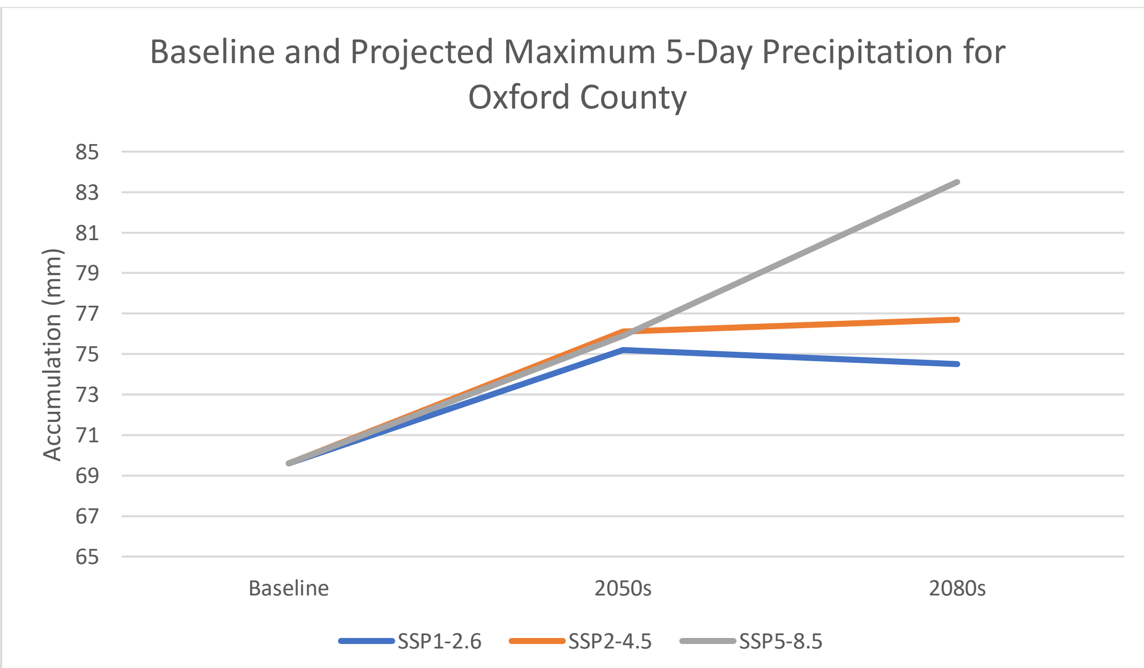
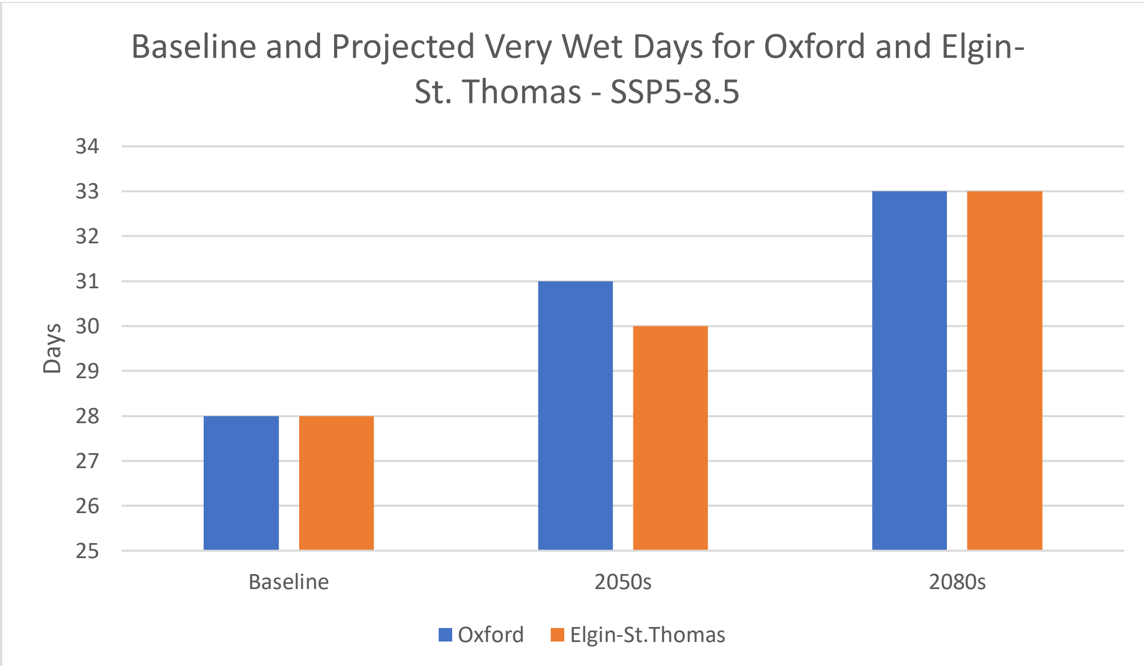


Figure 14: Baseline and Projected Heavy Precipitation Days for Oxford County and Elgin County and the City of St. Thomas - SSP5-8.5



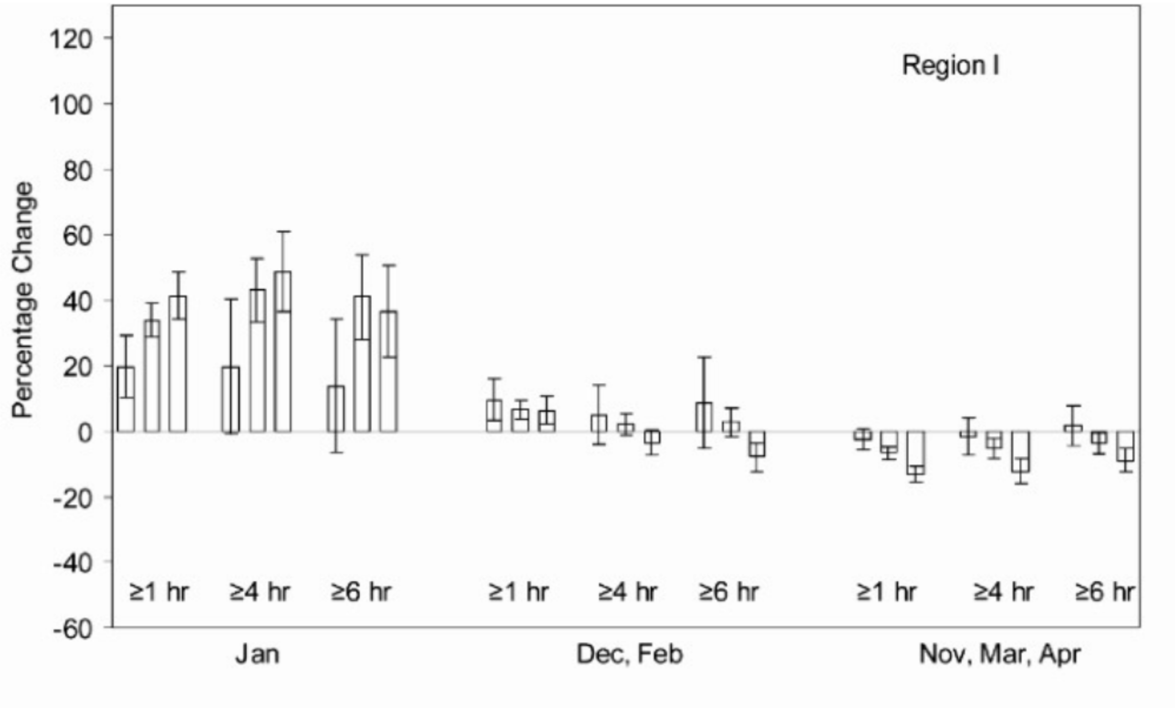
Freezing Rain

The potential effects of climate change on freezing rain in Eastern Canada were conducted in a collaborative study by the Meteorological Service of Canada and the Science and Technology division of Environment and Climate Change Canada. For their analysis, the researchers used downscaled future climate scenarios from the IPCC Fourth Assessment Report.

Region I of the study focuses on a section of Southwestern Ontario, which covers Oxford County and Elgin County and the City of St. Thomas (Table 15). The projected average percentage changes in the frequency of freezing rain events on a daily basis were the main focus of the analysis. The average percentage changes in the number of daily freezing rain events lasting longer than one hour, four hours, and six hours are shown in Figure 15 [(17)].

With minor changes in December and February, and an overall decrease in November, March, and April, the largest percentage increase in freezing rain occurs in January for Region I. Severe freezing rain events lasting over six hours per day are anticipated to rise by up to 30% by the year 2100 [(17)].

Figure 15: The average percentage change in the number of daily freezing rain events (%) for Region I relative to 1957-2007 baseline conditions



Source: Cheng et al., 2011

Air Quality

Ontario ministry in collaboration with the federal National Air Pollutant Surveillance (NAPS) program, actively monitors the real-time ambient air quality in 39 air monitoring stations located in various communities across Ontario. Air quality measurements conducted in Canada and Ontario over the past few decades have shown notable decreases in harmful air pollutants that can be attributed to emissions from vehicles and industries.

Air quality in Ontario is subject to fluctuations on an annual basis due to multiple factors, including pollutant emissions, weather conditions, extreme weather events such as forest fires, and the transport of air pollutants from the United States and other regions. Therefore, as opposed to year-to-year variations, long-term trends offer a more accurate representation of any improvements or deteriorations in air quality over time [18].

Between 2011-2020, average sulphur dioxide (SO_2) concentrations decreased by 50%. Furthermore, average nitrogen dioxide (NO_2/NO_x) concentrations decreased by 25%, and particulate matter ($PM_{2.5}$) decreased 17%. Ground level ozone (O_3) decreased approximately 13% as shown in Table 26.

However, even with relatively low levels of air pollution in countries such as Canada, any incremental increase in the concentration of air pollutants is associated with an increased risk of adverse health effects. As a result, despite relatively lower pollution levels, air pollution continues to place a heavy burden on disease, highlighting the significance of addressing this issue. An estimated total of 15,300 premature deaths occurs in Canada each year, out of which approximately 6,600 deaths occur prematurely in Ontario, as a result of the presence of three major air pollutants: fine particulate matter ($PM_{2.5}$), ozone, and nitrogen dioxide, with an economic cost of $114 billion [19][20]. It is recognized that being exposed to significant air pollutants, such as ozone and $PM_{2.5}$, increases the risk of many adverse health effects in the general population. These outcomes can range from respiratory symptoms to the development of diseases and premature mortality. Therefore, addressing these air pollutants is essential for preserving the population's general health in Canada [19].

Table 26: Trends in Common Air Pollutants in Ontario, 2011-2020

Pollutant	Concentrations	Emissions
Nitrogen dioxide/ Nitrogen oxides (NO_2/NOx)	-25%	-36%
Fine particulate matter ($PM_{2.5}$)	-17%	-18%
Sulphur dioxide (SO_2)	-50%	-57%
Ground-level ozone (O_3)	-13%	N/A

Source: Air Quality in Ontario, 2020

The Canadian Ambient Air Quality Standards (CAAQS) were introduced in 2013 under the Canadian Environmental Protection Act, creating more stringent targets for pollutants and setting annual standards for ozone and $PM_{2.5}$. Territories and provinces were required to report ambient air quality measurements in accordance with the CAAQS as of 2015. In 2020, new standards for these pollutants were introduced. The standards for the year 2025 are also given in the table.

The CAAQS sets annual standards of 8.8 ug/m3 and a 24-hour standard of 27 ug/m3 for PM2.5. The 8-hour standard for ozone is set at 62 ppb, while the 1-hour and annual standards for nitrogen dioxide are 60 ppb and 12.0 ppb, respectively. The CAAQS standards for fine particulate matter, ozone, sulphur dioxide, and nitrogen dioxide are shown in Table 27. However, it is crucial to understand that there is still a chance for adverse health effects to occur even when air pollutant concentrations fall within these standards.

Table 27: CAAQS Standards for Fine Particulate Matter, Ozone, Sulphur Dioxide, and Nitrogen Dioxide[7]

Pollutant	Averaging time	Numerical value			Statistical form
		2015	2020	2025	
Fine Particulate Matter ($PM_{2.5}$)	24-hour	28 μg/m^3	27 μg/m^3		The 3-year average of the annual 98th percentile of the daily 24-hour average concentrations
	Annual	10.0 μg/m^3	8.8 μg/m^3		The 3-year average of the annual average of the daily 24-hour average concentrations
Ozone (O_3)	8-hour	63 ppb	62 ppb	60 ppb	The 3-year average of the annual 4th highest of the daily maximum 8-hour average ozone concentrations
Sulphur Dioxide (SO_2)	1-hour	-	70 ppb	65 ppb	The 3-year average of the annual 99th percentile of the SO_2 daily maximum 1-hour average concentrations
	Annual	-	5.0 ppb	4.0 ppb	The average over a single calendar year of all 1-hour average SO_2concentrations

[7] Source: Canadian Ambient Air Quality Standards

Nitrogen Dioxide (NO_2)	1-hour	-	60 ppb	42 ppb	The 3-year average of the annual 98th percentile of the daily maximum 1-hour average concentrations
	Annual	-	17.0 ppb	12.0 ppb	The average over a single calendar year of all 1-hour average concentrations

Source: Canadian Ambient Air Quality Standards

The Ontario Ministry of the Environment has established the Ambient Air Quality Criteria (AAQC) in addition to the Canadian Ambient Air Quality Standards (CAAQS). The AAQC defines target concentrations of air pollutants based on the desired levels of protection against adverse health and environmental impacts. In this context, "ambient" refers to overall air quality, regardless of location or specific sources of pollution. The Ontario Ministry of Environment, Conservation and Parks provided the AAQC standards for ozone, fine particulate matter, nitrogen oxide, and sulfur oxide. These standards are shown in Table 28.

Table 28: Ontario's Ambient Air Quality Criteria for Common Air Pollutants

Contaminant	**1-hour** AAQC	**8-hour** AAQC	**24-hour** AAQC	**Annual** AAQC
NO_2	200 ppb	-	100 ppb	-
$PM_{2.5}$	-	-	27 µg/m^3	8.8 µg/m^3
O_3	80 ppb	-	-	-
SO_2	40 ppb	-	-	-

Source: Ontario's Ambient Air Quality Criteria

The Port Stanley air quality monitoring site serves as the monitoring station for assessing air quality in Elgin County and the City of St. Thomas region. The Kitchener/London air quality monitoring site is responsible for evaluating the air quality in Oxford County. For this report, the data from the Kitchener station has been used for assessing air quality in Oxford County. Table 29 shows the annual air pollutant statistics acquired in the Kitchener and Port Stanley Station for nitrogen dioxide, particular matter, and ozone for the year 2021.

Table 29: 2021 Annual Air Pollutant Statistics

AQHI Station	Air pollutants	Maximum 1-hour	Maximum 24-hour	Annual mean
Kitchener	Nitrogen dioxide	44.2 ppb	19 ppb	4.81 ppb
	Particulate matter	57 µg/m^3	36 µg/m^3	7.8 µg/m^3
	Ozone	81 ppb	58 ppb	28.4 ppb
Port Stanley	Nitrogen dioxide	21.3 ppb	6.85 ppb	2.20 ppb
	Particulate matter	66 µg/m^3	28 µg/m^3	7.0 µg/m^3
	Ozone	74 ppb	59 ppb	31.4 ppb

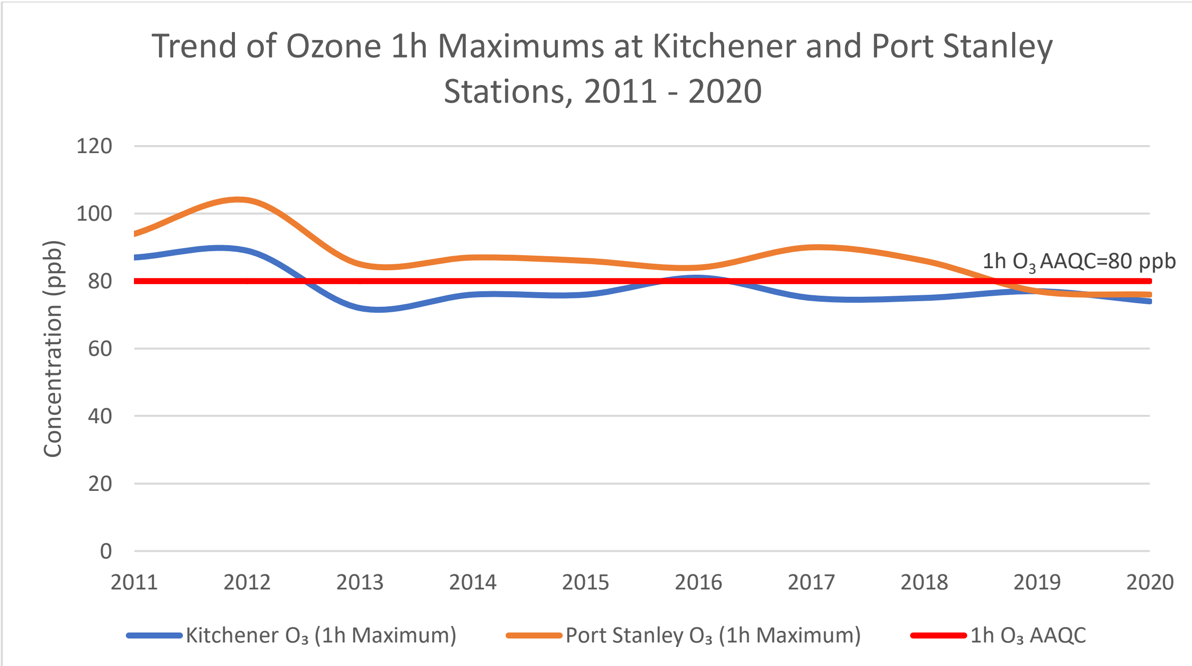
Source: Ontario Annual Air Pollutant Statistics

Ground-level Ozone

Ground-level ozone, a major constituent of smog, is generated when nitrogen oxides (NOx) and volatile organic compounds (VOCs) react in the presence of sunlight. In Ontario, higher ground-level ozone concentrations happen between May and September, when there are more hot, sunny days, primarily during noon to early evening. Unlike NOx emissions, which are almost exclusively the result of human activities related to the burning of fossil fuels, VOCs can come from both anthropogenic (man-made) and natural sources. However, the main sources of both NOx and VOCs are frequently connected to products and infrastructure used in transportation, like road vehicles and solvents.

Ozone is harmful to the respiratory system and can irritate the eyes and respiratory tract. When exposed to ozone, people who are sensitive to it may develop symptoms like wheezing, coughing, and tightness in the chest. Children are particularly vulnerable, especially those who participate in outdoor activities in the summer when ozone levels are at their highest. Individuals who already have breathing problems like asthma or chronic obstructive pulmonary disease are also at risk. Increased hospital admissions and early deaths have been linked to ozone [(21)]. Figure 16 shows that there is a decreasing trend by 19.1% in ground-level ozone 1-hour maximum over the 10 years period in Port Stanley station. On the other hand, the Kitchener station demonstrates a slight decline of 5.2% in the ground-level ozone 1-hour maximum, therefore, no significant trend in ozone concentrations is observed over the 10 years. The summer mean also shows a significant decreasing trend by 12% over the ten-year period. However, there were no significant trends detected for winter ozone mean over this period.

Figure 16: Trend of Annual Ozone Means at Kitchener and Port Stanley Stations, 2011-2020



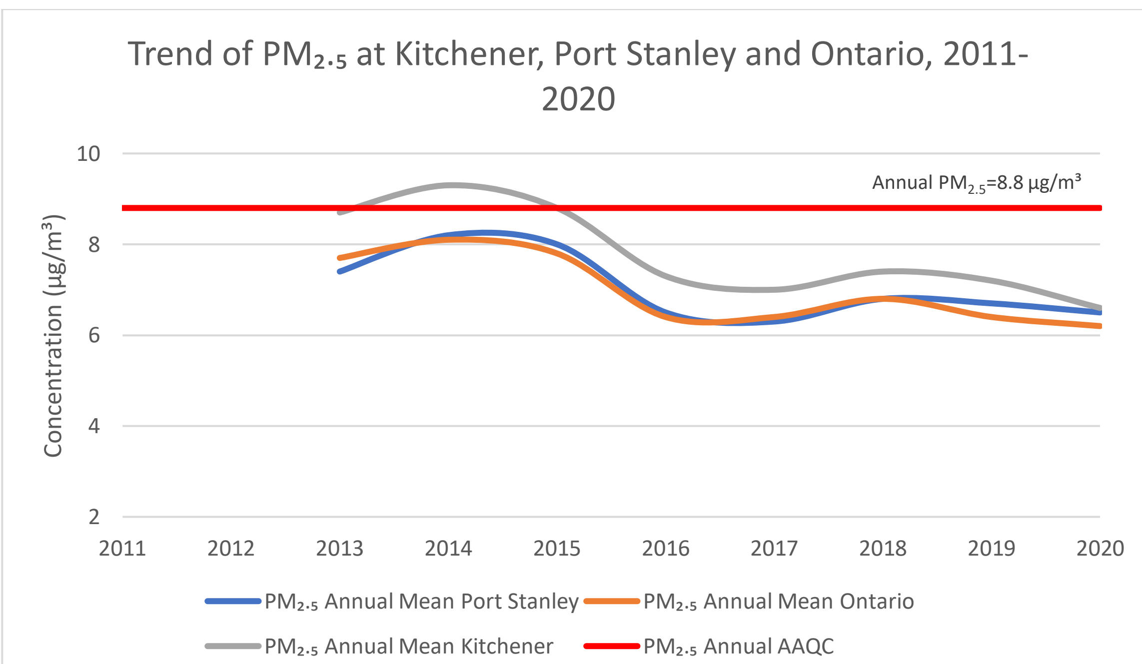
Source: Air Quality in Ontario, 2020. Data extracted from: https://www.ontario.ca/document/air-quality-ontario-2020-report/10-year-trends-and-annual-results#section-2

Particulate Matter

Particulate matter is a term used to describe a variety of small particles suspended in the air, including aerosols, smoke, fumes, dust, fly ash, and pollen. Depending on the source, atmospheric conditions, season, and environmental factors, Particulate matter can have a different composition. Particulate matter is frequently categorized based on its diameter because different sizes of particulate matter have different health effects. Of particular importance in discussions about air quality is $PM_{2.5}$, which denotes fine particulate matter with a diameter equal to or less than 2.5 microns. Due to their small size and ease of inhalation, $PM_{2.5}$ particles are frequently used as a general indicator of air quality. $PM_{2.5}$ is directly released into the atmosphere from a variety of sources, including motor vehicles, smelters, power plants, industrial buildings, agricultural burning, and forest fires. Other sources include residential fireplaces and wood stoves, motor vehicles, and industrial facilities [22].

Exposure to $PM_{2.5}$ is linked to a range of adverse health effects, including increased hospital admissions, serious health complications, and premature death. These risks are particularly evident in vulnerable groups like children, the elderly, and individuals with lung disorders, asthma, or cardiovascular diseases. $PM_{2.5}$ can have adverse impacts on public health both in the short term, such as within a single day, and over the long term, with chronic exposure to $PM_{2.5}$ over a period of years or more [20]. Long-term exposure to $PM_{2.5}$ particles increases the risk of adverse respiratory effects, including worsened respiratory symptoms and impairment of lung development in children. It has been connected to cardiovascular effects; particularly affecting health parameters linked to the development of atherosclerosis [19]. New findings suggest that it may also have negative effects on the nervous system, including the development of dementia [19][23], as well as number of other health issues, including metabolic disorders like diabetes and unfavorable pregnancy outcomes like low birth weight [19][24]. Figure 17 illustrates that between 2011 and 2020 period, there has been a 17% reduction in the average annual concentrations of fine particulate matter throughout Ontario. However, although the change over 10 years show a decreasing trend in Port Stanley station by 18.4%, it is slightly higher than the particulate matter annual mean recorded in Ontario in 2020. Similarly, there is a significant decline of 20.8% reduction recorded in Kitchener station for $PM_{2.5}$ over the 10 years, however, the particulate matter annual mean is slightly higher at 6.6 µg/m³ than that of Ontario at 6.2 µg/m³.

Figure 17: Trend of Annual $PM_{2.5}$ Means at Ontario, Kitchener and Port Stanley Stations, 2011-2020



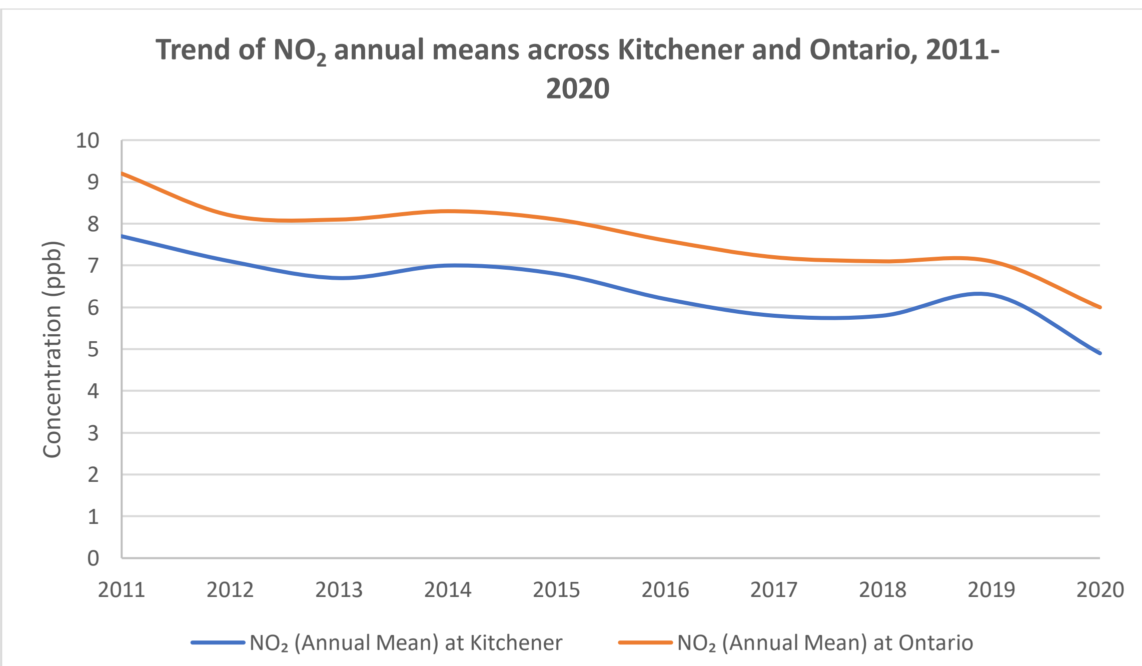
Source: Air Quality in Ontario, 2020. Data extracted from: https://www.ontario.ca/document/air-quality-ontario-2020-report/10-year-trends-and-annual-results#section-1

Nitrogen Dioxide

Nitrogen dioxide (NO_2) is a reddish-brown color gas and has a strong odor. When present in the atmosphere, it goes through chemical changes and helps to form nitrates and gaseous nitric acid. It has a significant impact on the atmospheric reactions that result in the creation of ground-level ozone, a crucial element in the formation of smog. In addition, nitrogen dioxide reacts in the air and contributes to the creation of $PM_{2.5}$. According to the Ontario Ministry of the Environment, in 2016, the transportation industry, industrial processes, and the production of electricity are the primary sources of nitrogen dioxide emissions.

Nitrogen dioxide can irritate the respiratory system and reduce the body's ability to fight off infections of the lungs. People who have bronchitis and asthma are especially vulnerable to the effects of nitrogen dioxide [(22)]. According to Figure 18, there has been a significant decrease of 22% in the average annual levels of nitrogen dioxide recoded in the Kitchener station between the years 2011 and 2020. Overall, there has been a 25% reduction in the average annual concentrations of nitrogen dioxide throughout Ontario from the year 2011 to 2020. The average annual mean of nitrogen dioxide is slightly higher in Ontario at 6ppb than in Kitchener at 4.87ppb.

Figure 18: Trend of NO_2 annual means across Ontario, 2011-2020



Source: Air Quality in Ontario, 2020. https://www.ontario.ca/document/air-quality-ontario-2020-report/10-year-trends-and-annual-results#section-0

Projecting Future Air Quality

As per the Ontario Climate Change and Health Modeling Report, it is anticipated that as average temperatures increase, the frequency of air pollution events will also rise [(25)]. In accordance with the 1-hour AAQC for ozone, the report from 2016 predicted an annual rise in the number of days in Ontario's Public Health Unit jurisdictions that exceeded the 80-ppb threshold. The average ozone concentrations for the baseline period are shown in Table 30 of the report, along with projections for the 2050s and 2080s.

In Elgin County and the City of St. Thomas and Oxford County, the baseline period from 1971 to 2000 witnessed 12 and 2 days respectively where the 80 ppb of ozone concentrations limit was exceeded (Table 30). However, for the 2050s, Elgin County and the City of St. Thomas are projected to exceed limit for 14 days and 3 days for Oxford County. By the 2080s, Elgin County and the City of St. Thomas are projected to exceed the limit 15 days of the year, while the count for Oxford County remains unchanged from the 2050s [(25)].

Table 30: Changes in number of ozone exceedances (> 80 ppb) count (days per year) by PHU in southern Ontario for the baseline period (1971-2000) and two projection periods (2050s) and (2080s)

Public Health Units	Days above 80 ppb (1971-2000)	Days above 80 ppb (2050s)	Days above 80 ppb (2080s)
Oxford County	2	3	3
Elgin County and the City of of St. Thomas	12	14	15

Source: Ontario Climate Change and Health Modelling Study, 2016

Wildfires have an impact on ozone (O_3) and particulate matter (PM), which are crucial factors affecting air quality, climate change, and human health. Wildfire exposure has been associated with a number of adverse health outcomes, including cardiovascular disease mortality, and acute myocardial disease mortality, higher rates of morbidity (primarily respiratory diseases), mental health disorders, stunted growth in children, decreased lung function, and general worsening of health [(26)]. Wildfires are predicted to become more frequent and intense under the influence of a changing climate, increasing air pollution both inside and outside in impacted areas [(19)].

The Human Health Chapter of the 2014 Canada in a Changing Climate Report, simulations of 10 summer seasons are compared between current (2000) and future (2045) air quality in North America. It suggests that under climate change, while keeping anthropogenic air pollutant emissions constant, ozone concentration changes in Canada are generally less severe than the United States, with local increases of 4 to 5 parts per billion by volume (ppbv) observed in certain areas of southern Ontario and 1 to 2 ppbv in various parts in rest of the country as illustrated in Figure 19 (top figure) [(27)]. The study also explored at the possibility of reduced emissions of anthropogenic air pollutants. Even with the effects of climate change taken into account, Canada could experience significant drops in ozone concentrations of 5 to 15 ppbv.

The same simulations used to analyze ozone concentrations also provide insights into the changes in fine particulate matter ($PM_{2.5}$) levels in North America under climate change. According to the study, these simulations predict relatively smaller increases in $PM_{2.5}$ concentrations across most of North America, typically below 0.2 micrograms per cubic meter ($\mu g/m^3$) (bottom figure) [(27)].

Figure 19: Visualization of Ten-year Averages for Daily Summer Maximum Concentrations of Ozone (on top) and Fine Particulate Matter (on bottom)

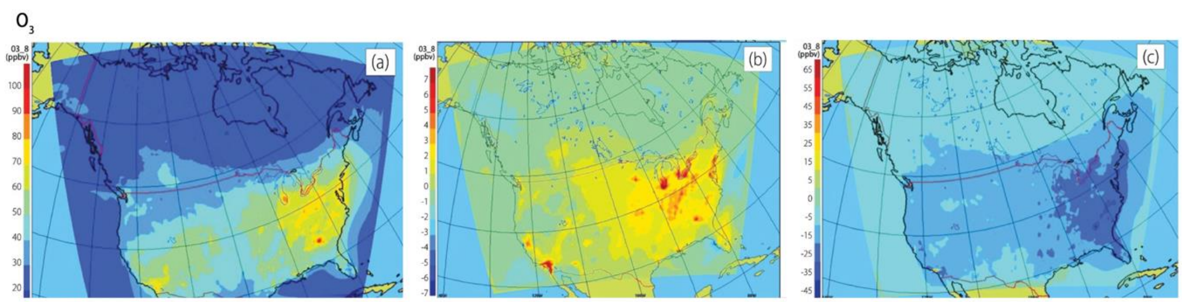


FIGURE 1: **a)** The ten year average "current" mean summer (June-July-August) daily maximum 8-hour average O_3 concentration; **b)** projected changes in the summer average daily maximum 8-hour O_3 between the "current" case and the "future" case with climate change using constant air pollutant emissions; and the **c)** "current" case and "future" case with possible reductions in future air pollutant emissions *(Source: Kelly et al., 2012)*. Note the different contour intervals used in each panel.

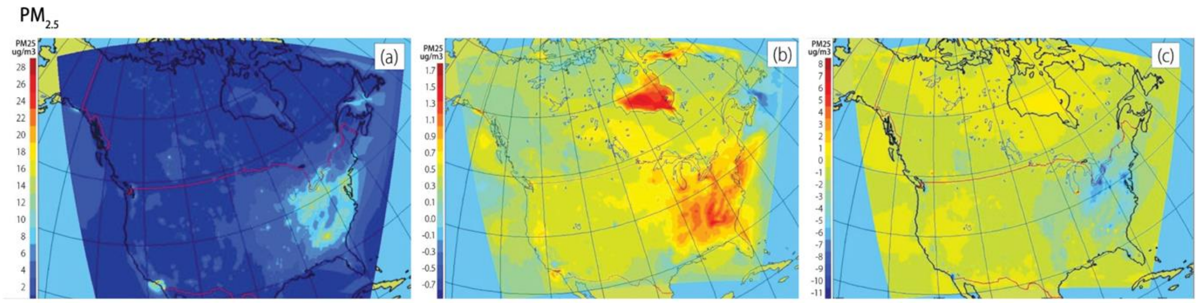
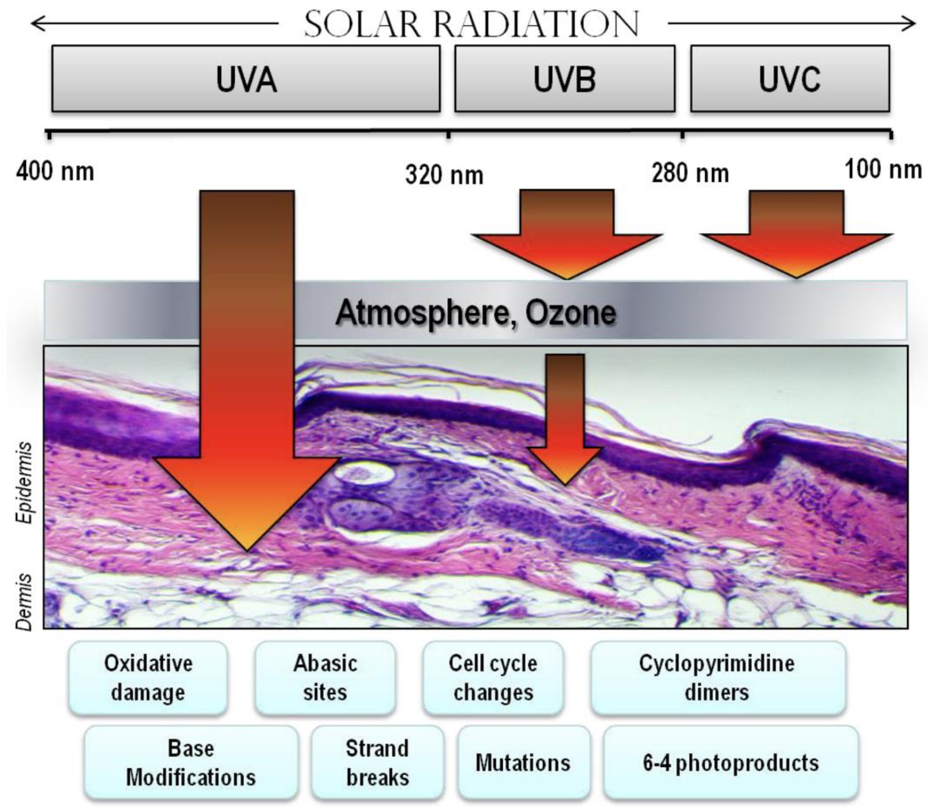


FIGURE 2: **a)** The ten year average "current" mean summer (June-July-August) 24-hour average $PM_{2.5}$ concentration; **b)** projected changes in the summer 24-hour average $PM_{2.5}$ concentration due to climate change with constant air pollutant emissions; and **c)** projected changes to $PM_{2.5}$ for the future with the combined effects of climate change and possible future decreases in air pollutant emissions *(Source: Kelly et al., 2012)*. Note the different contour intervals used in each panel.

UV index

The UV Index, which ranges from 0 to 11+ in Canada, indicates stronger sun rays with higher UV index. To illustrate, the UV index is categorized into five risk levels: Low (0-2), Moderate (3-5), High (6-7), Very High (8-10), and Extreme (11+). Sun safety precautions need to be taken more seriously when the UV index increases. UV exposure causes sunburn, eye cataracts, aging skin, and skin cancer and is influenced by both the length of time spent in the sun and its intensity, as measured by the UV Index [(28)]. Figure 20 illustrates the three types of UV radiation with each having distinct effects on the health of the population [(29)]. UV-A is the least powerful type of UV rays, but it can still cause damage to the skin, leading to sunburn and early aging. However, UV-B rays are stronger than UV-A and are primarily responsible for sunburns and skin damage that can lead to skin cancer [(30)]. In contrast, UV-C rays do not reach the Earth's surface because the ozone layer effectively absorbs them entirely [(29)].

Figure 20: Three Types of Solar UV Radiation and Biologic Effects on the Skin

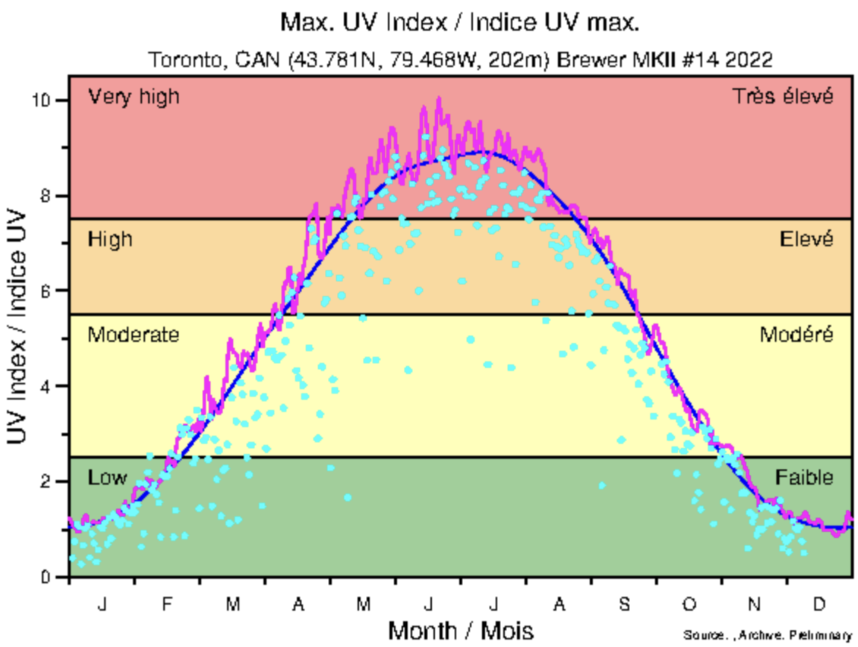


There is no direct relationship between UV radiation and temperature (heat). Unlike infrared radiation, which causes heat to be felt on skin, UV radiation is invisible and cannot be sensed. Along the electromagnetic spectrum, the sun emits different kinds of radiation, and the radiation that produces heat is different from the radiation that causes skin cancer and other health problems (31).

The highest levels of UV radiation from the sun occur during solar noon, typically between 12 and 1 p.m. throughout Canada. During this period, the sun's rays have a shorter distance to travel through the atmosphere, intensifying the UV intensity. Generally, between 11 a.m. and 3 p.m., the UV Index in Canada can reach 3 or higher (32).

The earth's ozone layer protects against the detrimental UV rays emitted by the sun, safeguarding us from their harmful effects. The ability of the ozone layer to shield the earth from the sun's harmful UV rays has decreased over time due to the thinning of the layer due to the release of particular chemicals into the environment. As a result, more UV radiation hits the Earth's surface [32]. However, as part of a comprehensive strategy to address this issue, Canada has discontinued the production of ozone-depleting chemicals and control their usage by implementing regulations under the Canadian Environmental Protection Act [32]. Figure 21 shows the average highest UV Index recorded in Toronto for each month of 2022. The highest UV Index values are found in the summer, but elevated levels were also seen in April of that year.

***Figure 21:** Maximum UV Index in Toronto, Canada, 2022*



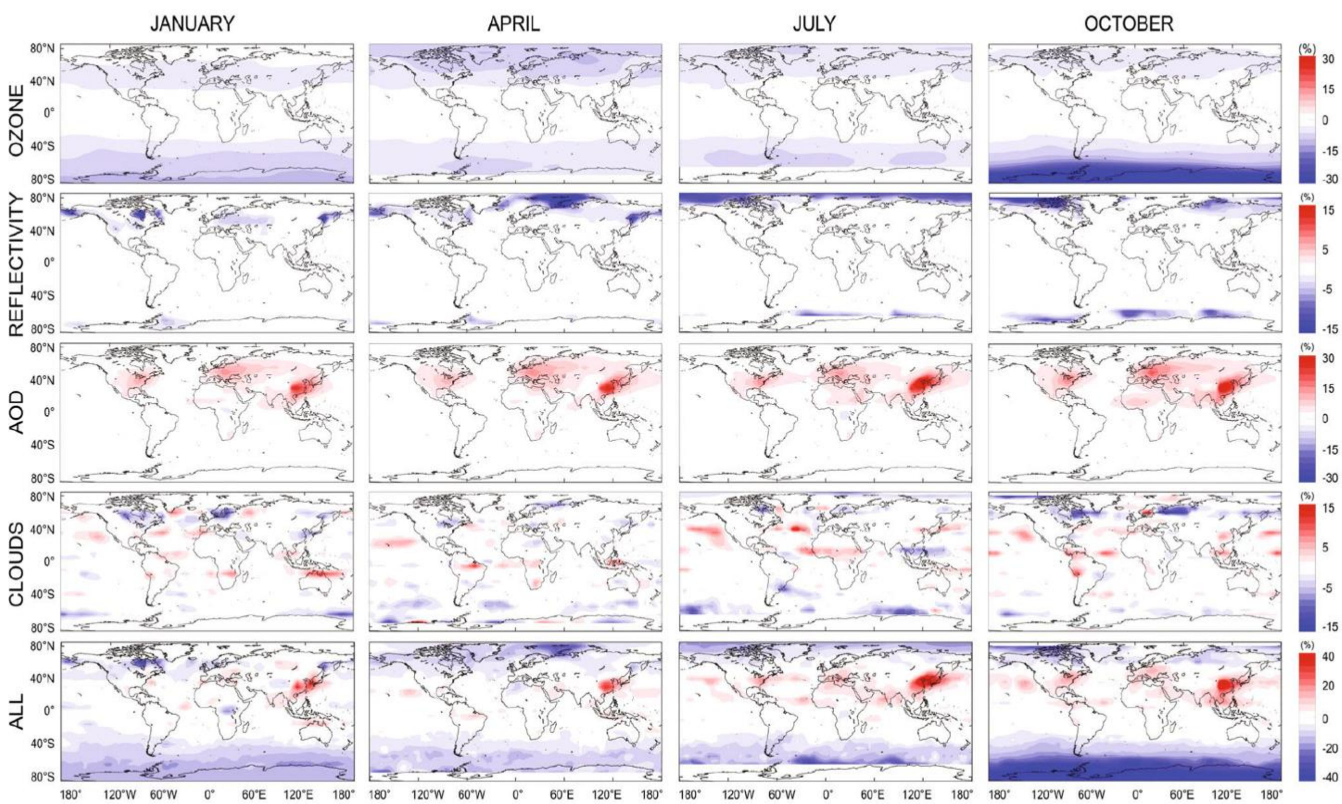
Source: [Environment and Climate Change Canada, 2022]

Projecting UV index

Future changes in the levels of solar ultraviolet (UV) radiation reaching the Earth's surface, including UV-B and UV-A, will be influenced by changes in aerosols (particles suspended in the atmosphere), future state of the ozone layer, clouds, and surface albedo (such as snow and ice coverage) [33]. Furthermore, impacts of stratospheric ozone due to the presence of Ozone Depleting Substances can also impact UVI, and climate change can further influence UVI levels through its impact on ozone, cloud cover, aerosols and surface reflectively [34]. Several studies (Bernhard et al., 2023; Lamy et al, 2019) validate the projected reduction in ultraviolet (UV) radiation as a result of the recovery of ozone in the stratosphere, especially in high and polar latitudes, as well as increases in UV radiation due to decreases in aerosol concentrations in regions with significant urban or industrial activities [35][36]. Furthermore, climate change-related factors such as diminishing ice cover and reduced cloudiness are important drivers leading to regional shifts (decreases and increases, respectively) in surface UV radiation levels [35].

A study conducted in 2019 by Bais et al. examined the potential effects of climate change and ozone depletion on global ultraviolet (UV) radiation levels. The researchers projected the noon Ultraviolet Index (UVI) under clear skies for different climate models using monthly data. These values were calculated using radiative transfer model. The study compared two 10-year periods: the current decade (2010-2020) and the future (2085-2095). Figure 22 illustrates the average differences in noon UVI across multiple models for four selected months. The projected changes in UVI can vary according to latitude and season, and can be attributed to different factors, such as ozone, aerosols, surface reflectivity, and clouds.

Figure 22: Average changes in noon-time UVI between decadal averages for the present day (2010–2020) and at the end of this century (2085–2095)



UVI values are projected to decrease during summer and autumn by 5-15% in the Northern Hemisphere due to reductions in surface reflectivity. However, there can be significant increases in the mid-latitude northern regions with locally reaching 40% higher UVI values. These increases are primarily attributed to projected decreases in aerosols over the most populated areas of the northern hemisphere [37]. The effects of aerosols on UV radiation levels in these regions can be further influenced by decreases in cloudiness, leading to higher UV radiation levels [37].

High Ultraviolet (UV) index levels during the summer and shoulder seasons will continue to be a major concern for Oxford County and Elgin County and the City of St. Thomas region. Although there is less certainty that climate change will increase UV radiation in Canada, ozone-depleting substances (OCDSs) continue to be a long-term source of concern. Because of this, it is essential to continue monitoring efforts and create plans for dealing with high UV index days both now and in the future.

Conclusion

An overview of the current and future effects of climate change on population health in Oxford County, Elgin County and the City of St. Thomas is provided in this report. Rising temperatures, higher UV radiation levels, more precipitation, and more frequent and severe weather events are some of the effects of climate change that are expected to have a significant short- and long-term impact on the health of the local population. The purpose of the report is to create a foundation of the regional climate variables that affect population health both now and in the future. It intends to support Southwestern Public Health's assessment of the vulnerability of the public health system to climate change and its effects.

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