FINGERPRINTS CANADA

Review and Analysis of Detection and Attribution Studies Identifying the Fingerprints of Climate Change in Canada

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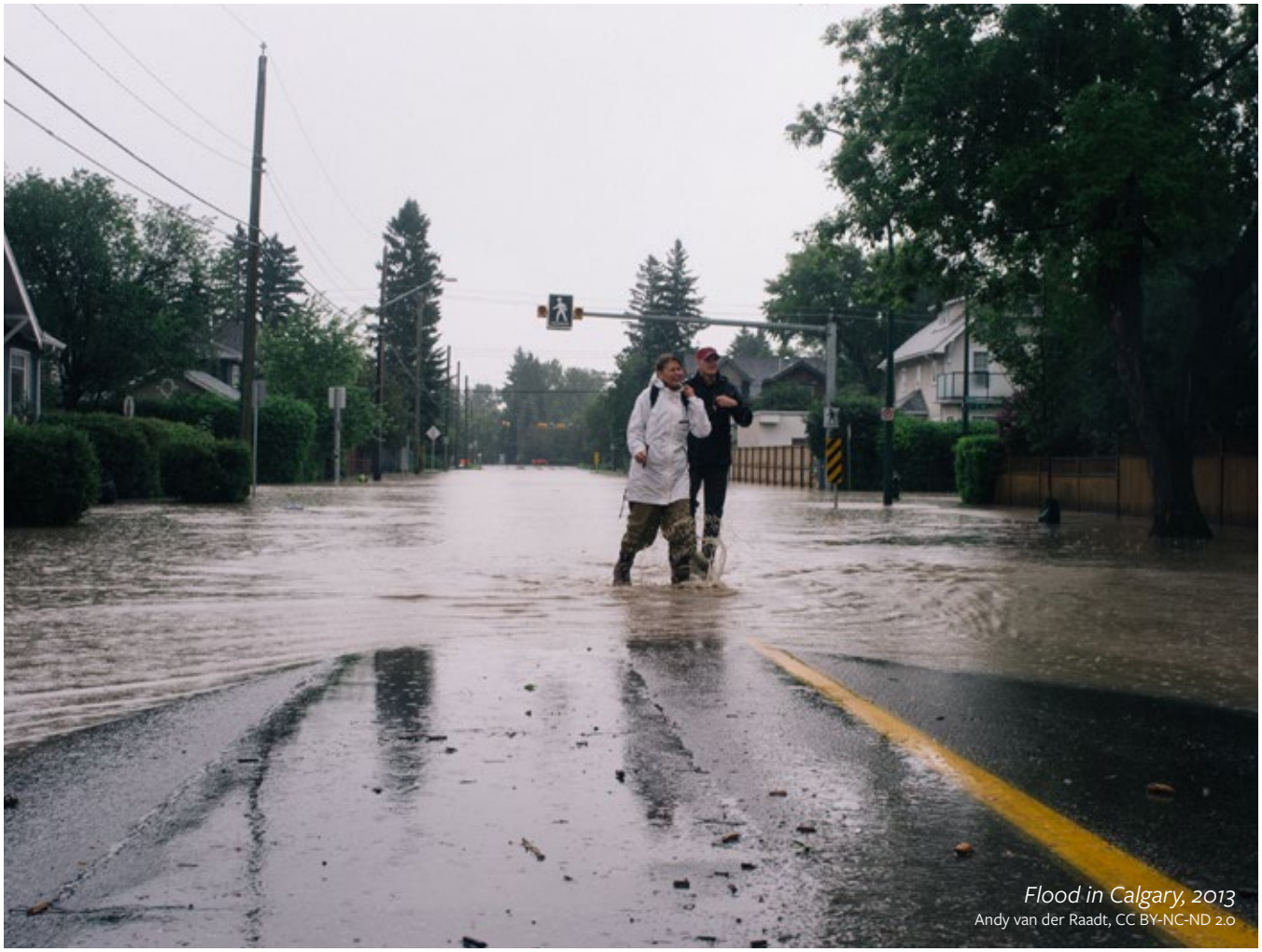


Flood in Calgary, 2013
Andy van der Raadt, CC BY-NC-ND 2.0

INTRODUCTION

In 2018, Climate Signals conducted a detection and attribution literature review of climate change studies since the 1990s.[1] It showed that human-caused climate change has had a significant and direct influence on many observed trends and events in the United States.

This report adapts and extends that approach to Canada, which has seen a number of extreme events in recent years that bear the fingerprints of climate change. The studies presented here show that climate change has had a direct impact on seven extreme events in Canada, including floods, wildfires, heat waves, and droughts during the five years from 2013 through 2018.

Like its predecessor, this report is a response to the need to make attribution science more accessible. The report identifies the specific influence of human-caused global warming on observable impacts and closes the gap between greenhouse gas emissions and their consequences for humans.

BACKGROUND

DETECTION AND ATTRIBUTION SCIENCE IS CRYSTALIZING THE IMPACTS OF CLIMATE CHANGE

Detection and attribution studies demonstrate that the climate or a system affected by climate has changed, and this change cannot be explained by natural variability alone.[2] Attribution studies go one step further than detection studies by identifying the factors affecting a detected climate change and evaluating the relative contributions of these factors.[3]

The process of linking human emissions to the increase in global average temperature is sometimes referred to as "climate change fingerprinting," or just "fingerprinting".[4] When a trend or event shows the fingerprints of climate change, it means scientists have identified the influence of human-caused climate change on that observed trend or event.[5] This line of research is important because it provides definitive proof that climate change directly impacts Canadians and helps in the prediction and mitigation of future events.[6]

Melting sea Ice at Pond Inlet, Nunavut, Canada
GRID Arendal, CC BY-NC-SA 2.0

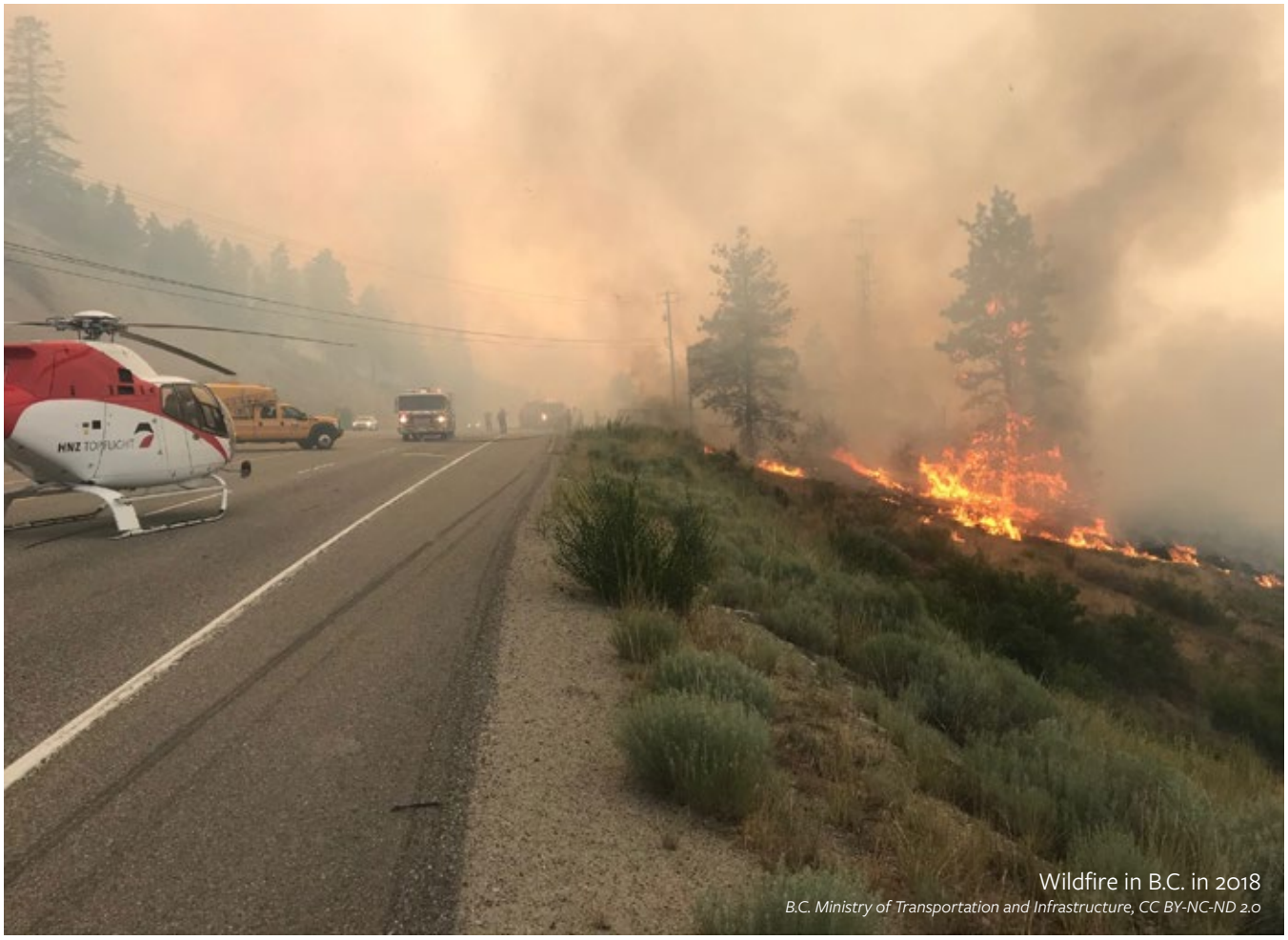
CLIMATE CHANGE IS IMPACTING REGIONS ACROSS CANADA

Human-caused climate change is making extreme weather events more frequent and severe globally, and Canada is no exception. The globally averaged combined land and ocean surface temperature data show a warming of 1.5°F (0.85°C) over the period 1880 to 2012.[7] The Arctic, which includes 39 percent of Canada's total land area, is warming even faster, at two-to-three times the rate of the global average.[8] The annual average temperature across Canada increased by about 1.7°C since 1948, with the most significant temperature increases occurring in the north, the Prairies, and northern British Columbia.[9]

According to the U.S. National Climate Assessment, the likely range of the human contribution to the global mean temperature increase over the period 1951–2010 is 1.1° to 1.4°F.[10] This translates to a likely human contribution of 92 to 123 percent of the observed 1951–2010 change. Canada's Changing Climate Report, led by Environment and Climate Change Canada, "states that "the human factor" is the dominant cause of observed warming in Canada."[11]

Since the start of the 21st century, the number of extreme weather events has risen across Canada. According to the Actuaries Climate Index - a joint effort by insurance organisations across North America - between 1961 and 1990, extreme weather conditions in Canada (temperature, precipitation, wind speed, and seal level) exceeded monthly thresholds only five times.[12] However during the last decade alone, extreme weather exceeded monthly thresholds 12 times.[13] This increase is also reflected in public opinion. More than 60 percent of Canadians say they have personally experienced unusual weather caused by climate change, a significant increase compared to 2010.[14]

Globally, extreme weather events attract attention because they are considered rare and have significant impacts on societies and economies.[15] A large and rapidly growing body of scientific research demonstrates that human-induced climate change is now contributing to the intensity and frequency of these events.



Wildfire in B.C. in 2018
B.C. Ministry of Transportation and Infrastructure, CC BY-NC-ND 2.0

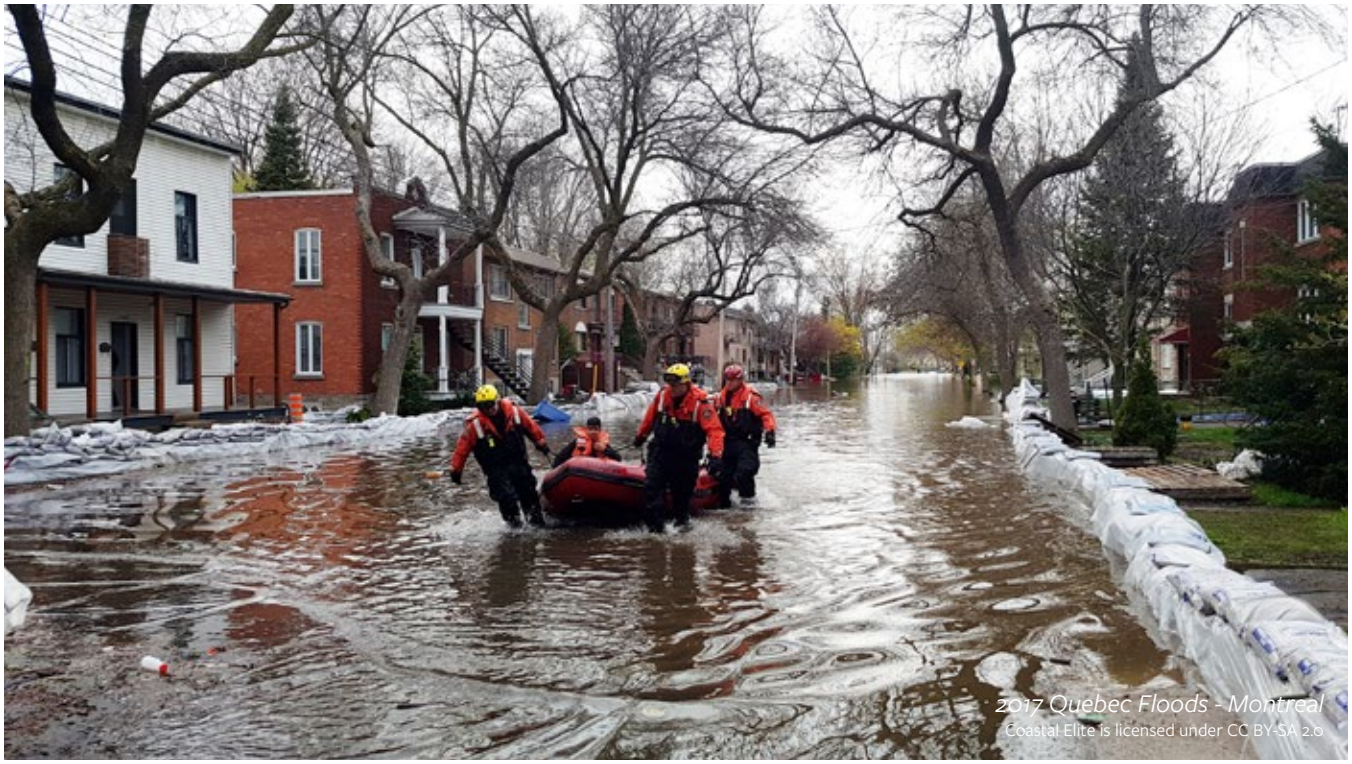
METHODOLOGY

This report adapts the foundations of the Fingerprints Everywhere 2018 report, but narrows the scope to include seven specific climate events in Canada from 2013 through 2018. It follows the same style of literature review, presenting the top-line results from seven attribution studies on floods, wildfires, heat waves, and droughts in Canada.

The following key sources were used to identify attribution studies on extreme weather events in Canada:

- Environment and Climate Change Canada & others: *Canada's Changing Climate Report*.[16]
- Bulletin of the American Meteorological Society: Extreme weather events that have impacted Canada detailed in the 2011-2017 reports *Explaining Extreme Events from a Climate Perspective*.[17]
- Carbon Brief: *Mapped: How Climate change affects extreme weather around the world*.[18]

The environmental, financial, and social costs of each event were obtained through a range of sources including government records, reporting by insurance companies, and news articles.



2017 Quebec Floods - Montreal

FLOODS

Over the past 100 years, the number of floods in Canada has increased. A growing percentage of precipitation now comes in the form of extreme events, with human-caused climate change directly responsible for much of this increase. Heavy rain contributes to flooding that is damaging buildings and roads, eroding soil, and putting people at risk. The lingering persistence of heavy precipitation events over affected areas has also exacerbated flooding across the country, especially in the Prairies where increased aridity can lead to greater runoff.[19]

Of the five most destructive floods since 2010,[20] three of them have been attributed to climate change by three separate attribution studies. The findings are presented below.

2017 QUEBEC FLOODS

In April and May 2017, heavy rains and rapid snowmelt alongside high water levels on the Great Lakes and the Ottawa River caused extensive flooding in southern Quebec and around Lake Ontario.[21] About 5,300 homes were flooded, 4,000 people were forced from their homes, and 286 municipalities were affected. Insured damages exceeded CAD$220 million in Quebec and Ontario.[22]

Events such as the heavy precipitation event during April 2017 over the Ottawa River basin are "between two to three times more likely to occur in the present-day climate as in the pre-industrial climate", according to a study by Teufel et al. (2019).[23] This study finds that the increased risk of heavy precipitation is linked to increased moisture in the air caused by warmer temperatures - a direct result of human-caused climate change.

2014 SASKATCHEWAN AND MANITOBA FLOODS

In 2014, a very cool spring delayed the onset of snowmelt across the south-eastern Prairies. This resulted in late spring melt lasting into late April, which meant soils in these areas did not have enough time to dry out before one of the stormiest and wettest May-June periods.[24] This was followed by widespread flooding which commenced in early July, bringing record rainfall to many parts of the region.

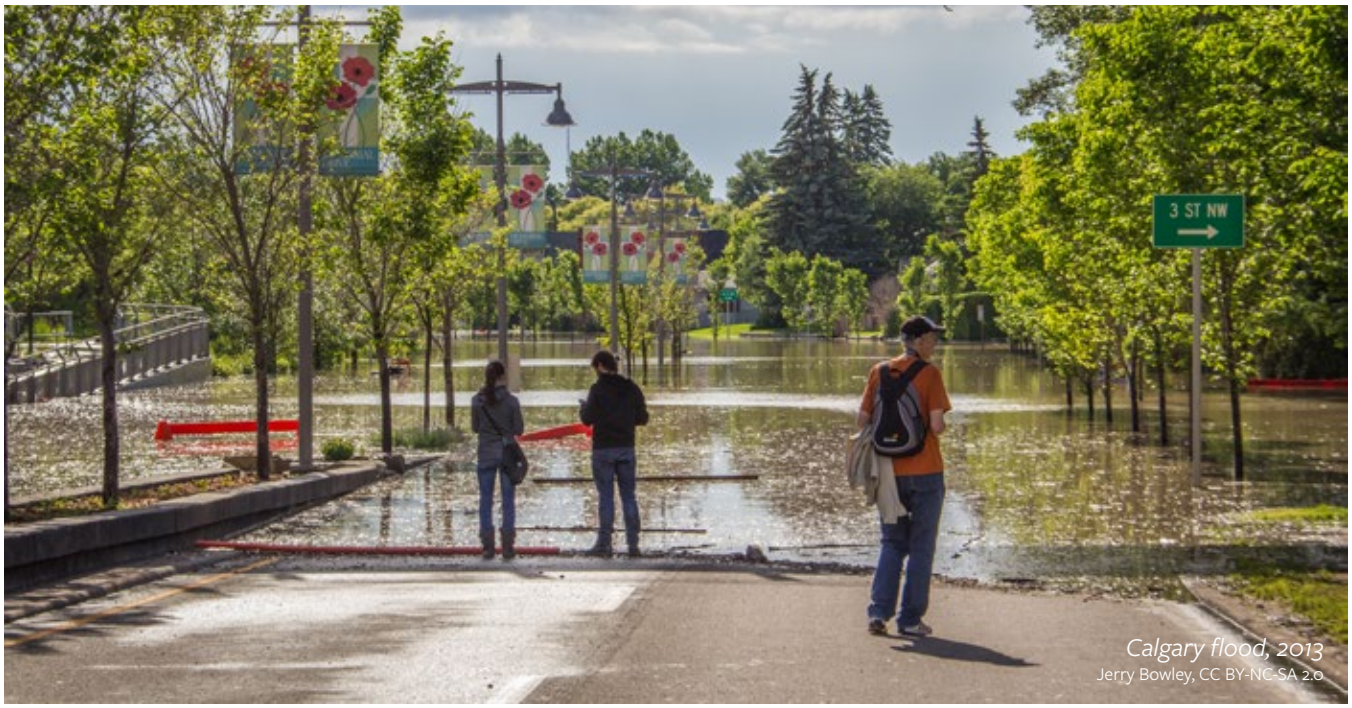
Highways were washed out, buildings flooded, and flights disrupted. The floods also destroyed about nine percent of Saskatchewan crops.[25] Eighty-seven out of 916 municipalities in Manitoba and Saskatchewan declared a state of emergency. Damages from the July 2014 floods cost the agricultural sector about CAD$1 billion alone.[26]

According to a study by Szeto et al., (2015), the May-June period has exhibited a significant increase in rainfall over the past five decades and human-caused climate change is responsible for at least a part of this trend in the southeastern Canadian Prairies.[27]

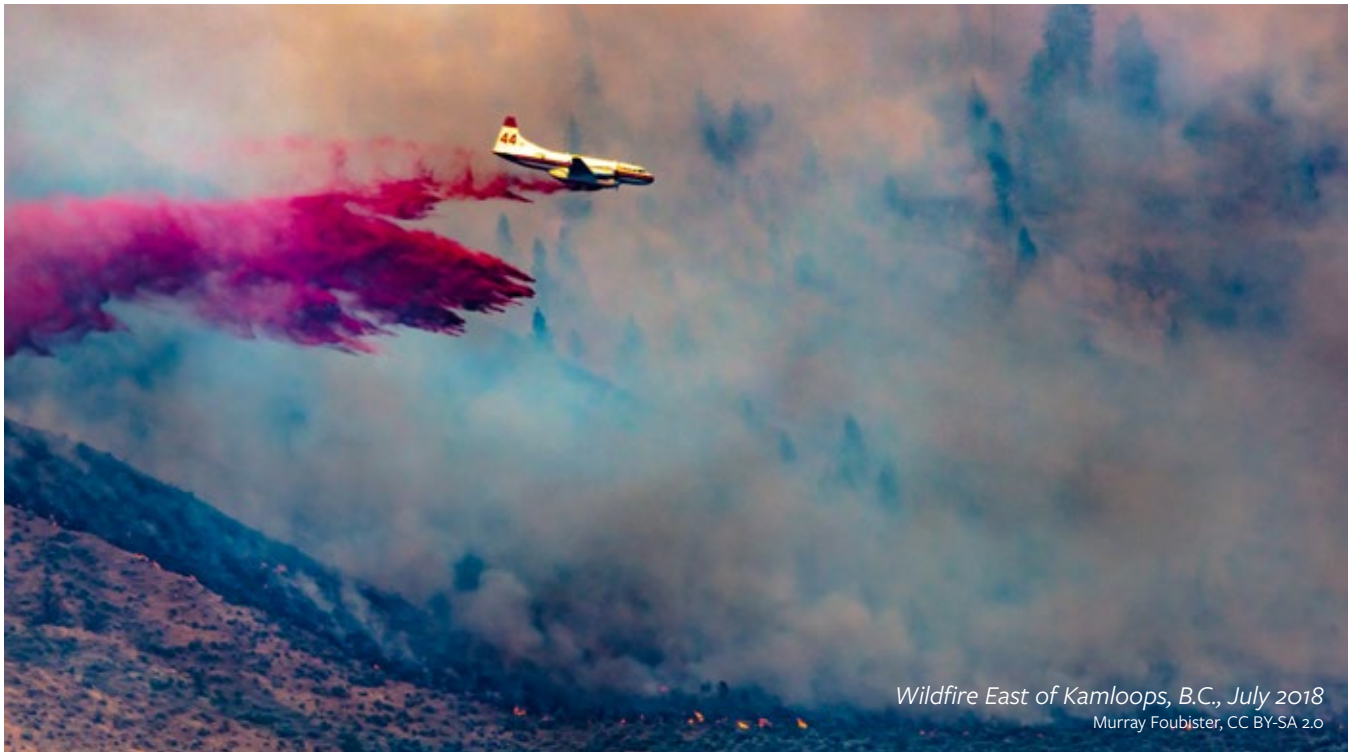
2013 ALBERTA FLOODS

Several precipitation-related factors set the stage for extreme flooding in Alberta in 2013. In late 2012, snow came early, the winter snowpack was deep and lasted into May, and recurring rainfall during spring saturated soils, increasing the risk of runoff.[28] The floods affected 25 percent of the province, forcing mass evacuations throughout the region and across Canada.[29] One thousand km of roads were destroyed[30] and about 300 bridges damaged.[31] More than 125,000 people were evacuated, making it the largest evacuation in Canada in more than 60 years.[32] These floods were one of the country's costliest, with damages and recovery costs reaching as much as CAD$6 billion, including a record CAD$2 billion in insured losses.[33]

According to Teufel et al., (2017), human-caused climate change likely increased one-day and three-day maximum precipitation levels.[34]



Calgary flood, 2013
Jerry Bowley, CC BY-NC-SA 2.0



Wildfire East of Kamloops, B.C., July 2018
Murray Foubister, CC BY-SA 2.0

WILDFIRES

In Canada, the amount of land burned each year is tied to the length of the fire season.[35] In 2017, 5,611 wildfires burned about 3.4 million hectares of land[36] - 1.3 million hectares more than the yearly average in Canada.[37]

As temperatures increase, water from plants and soils are drawn out, making trees, shrubs, and grassland dry and primed to burn. Subsequent wildfires are more likely to become uncontrolled and affect wildland areas, homes, and agricultural resources. Continued warming and decreased rainfall is expected to increase the frequency and severity of wildfires in Canada.[38] The following events are examples of how human-caused climate change has contributed to recent wildfires in Canada.

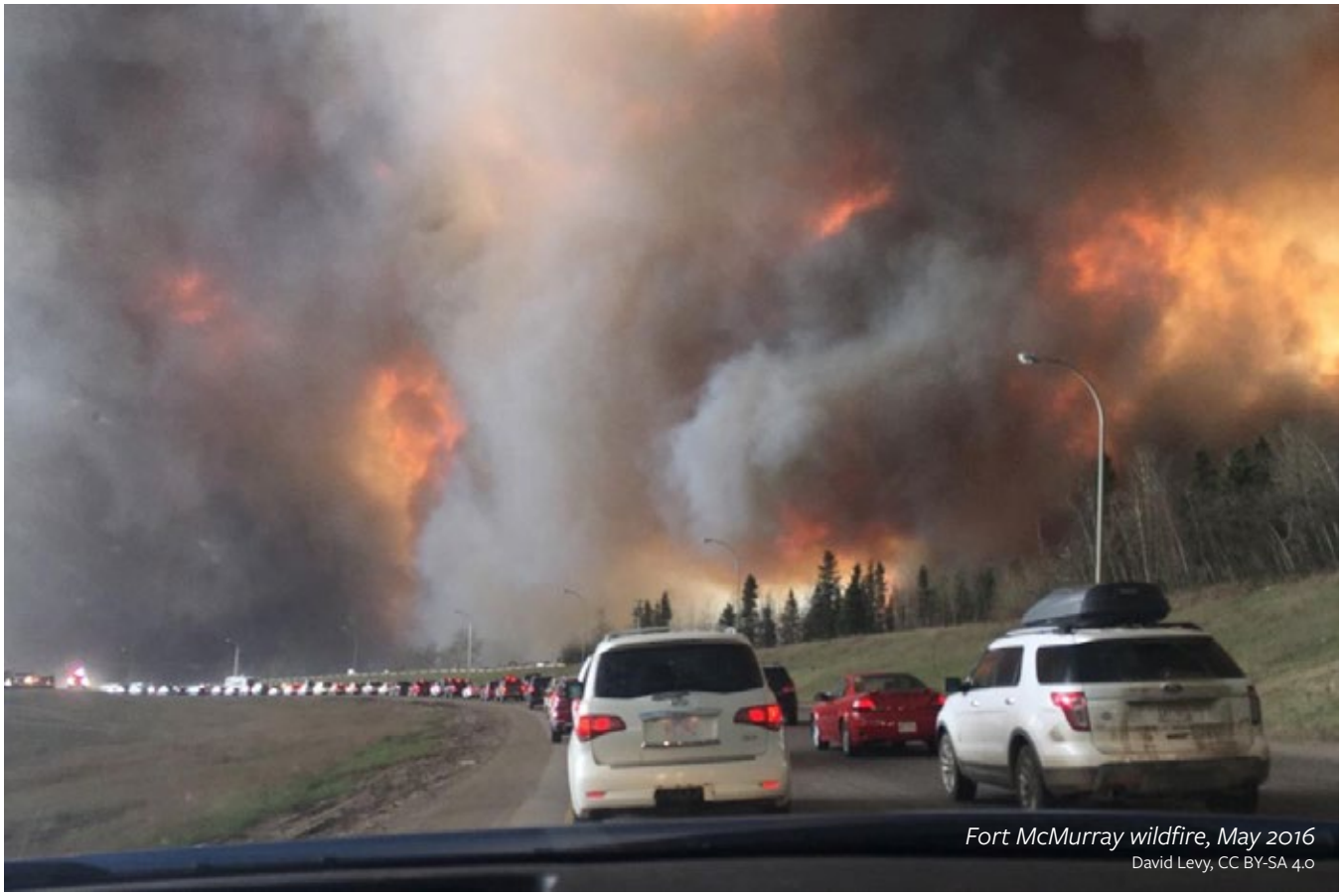
2017 BRITISH COLUMBIA WILDFIRES

Wildfires in British Columbia burned over 1.2 million hectares each year in both 2017 and 2018. This is about eight times larger than the expected ten-year average (161.9 hectares per fire) for the province.[39]

The summer of 2017 was long, hot, and dry, contributing to a high build-up of fuel and increasing fire risk.[40] Between July 6-8, widespread lightning strikes caused a major spike in wildfires in the Cariboo and Kamloops Fire Centre areas, which then spread rapidly across the province.[41]

The 2017 fires released an estimated 190 million tonnes of carbon dioxide emissions.[42] This is about 27 percent of Canada's total GHG emissions in 2017.[43] Putting out the fires cost over CAD$568 million, and about 65,000 people were evacuated.[44]

Human-caused climate change played a direct role by contributing to the dry conditions that fueled the fires in 2017. According to Kirchmeier–Young et al., (2018) human greenhouse gas emissions made the fires up to four times more likely and increased the area burned by up to 11 times.[45]



Fort McMurray wildfire, May 2016
David Levy, CC BY-SA 4.0

2016 FORT MCMURRAY WILDFIRES

On May 1, 2016, a wildfire started in a forested area seven kilometres outside Fort McMurray, Alberta.[46] By May 3, the fires spread throughout the community, making it the worst wildfire experienced in recent Canadian history. The fires forced almost 88,000 people from their homes, impacted 589,000 hectares of land,[47] and destroyed or damaged 1,958 structures. The Insurance Bureau of Canada estimated damages to have cost CAD $8.9 billion.[48]

Extremely dry conditions across Alberta in 2015, low snowpack over the winter, and hot and dry conditions in the spring all contributed to the event in 2016.[49] Snowpack changes affect the amount of water stored during the winter and released in the spring and summer.[50] These conditions were present in the week leading up to the Fort McMurray wildfires.

According to climate scientists, human-caused climate change has increased the length of the fire season and increased the risk of fires like the Fort McMurray fire.[51] Research by Tett et al., (2016) finds that human-caused climate change has increased the risk of extreme vapour pressure deficits (VPD) - which enhance wildfire risk - fivefold,[52] and according to Kirchmeier-Young et al., (2017) the combined influence of natural and human-caused climate change is "estimated to have made extreme fire risk events in the region 1.5 to 6 times as likely compared to a climate that would have been with natural forcings alone."[53]

HEATWAVES

Throughout Canada, climate change has increased average annual and seasonal temperatures. From 1948 to 2016, temperatures over Northern Canada increased by 2.3°C. This is about three times the average global warming rate.[54]

Human-caused climate change also affects extreme temperatures, generally making extreme warm temperatures hotter and extreme cold temperatures less cold.

Extreme heat events have increased across Canada since 1980.[55] This is consistent with increasing average temperatures which are causing extreme warm temperatures to become hotter.[56] Heatwaves are periods of consecutive, abnormally hot weather that occurs when a high-pressure system traps warm air and anchors it over a region.[57] These systems often prevent low-pressure systems that bring cooler, wetter weather, from entering. As the average temperature increases, heatwave risk increases.[58] Vulnerable populations living in dense metropolitan areas like Quebec and Ontario are especially at risk of heat-related illnesses such as heat exhaustion and heat stroke.[59]

JULY 2018 HEATWAVE IN QUEBEC

In July 2018, Quebec experienced a week-long heatwave in which temperatures exceeded 36°C.[60] The soaring temperatures combined with high humidity contributed to 74 deaths across the province, especially among the vulnerable and elderly. This was the second-deadliest heat wave since the summer of 2010, during which 106 people died.[61] According to a study by Vogel et al., (2019), the heat experienced simultaneously across several regions of the Northern Hemisphere would not have been as extensive as it was in the summer of 2018 without the influence of human-induced climate change.[62]

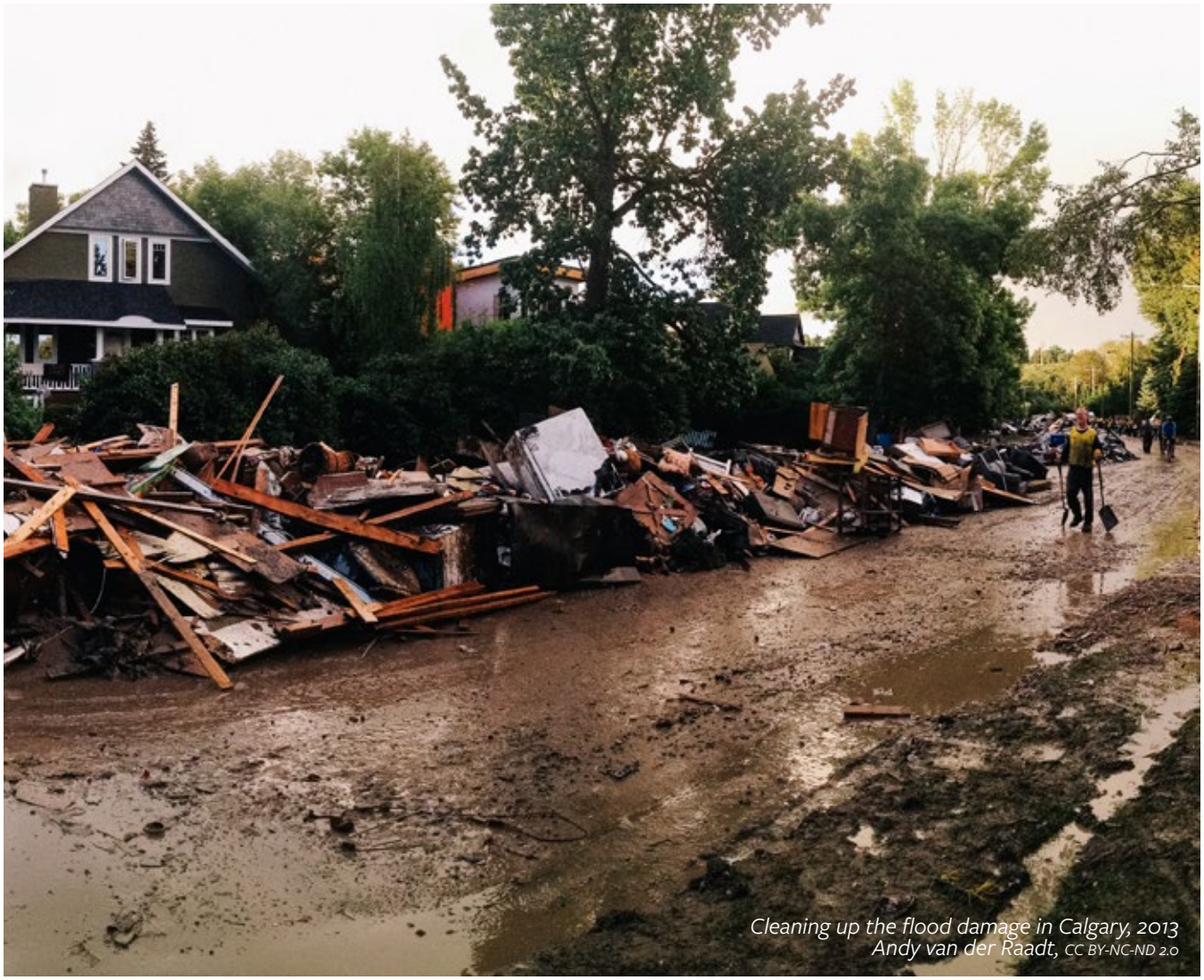
DROUGHT

During the first decade of the 21st century, droughts have become more frequent and severe, especially in parts of western Canada.[63] Droughts are caused by a multitude of contributing factors that affect ecosystems, agriculture, and humans.[64] Warmer temperatures can increase evaporation leading to early snowmelt and affect the ability of different soils and vegetation to hold water. The following event is an example of how human-caused climate change has increased drought risk in Canada.

2015 EXTREME DROUGHT IN WESTERN CANADA

During the spring and summer of 2015, western Canada experienced an extreme drought, severely impacting British Columbia and Alberta. Water restrictions were placed in British Columbia and the province was given the highest drought rating (level-4). Alberta experienced even drier conditions and the province was declared an Agricultural Disaster Area. The drought also fueled one of western Canada's worst wildfire seasons.[65]

Drought conditions damaged about 80 percent of provincial crops,[66] and according to Alberta's Agriculture Financial Services Corporation (AFSC), multi-peril crop insurance claims ranged from CAD$700 million to CAD$900 million.[67] According to Szeto et al., (2016) human-caused climate change likely caused the warmer temperatures experienced during the end of the winter season which in turn influenced the reduced snowpack, prompting the 2015 drought.[68]



Cleaning up the flood damage in Calgary, 2013
Andy van der Raadt, CC BY-NC-ND 2.0

CONCLUSION

In the last five years, attribution studies were conducted on seven major extreme weather events in Canada, all of which show clear fingerprints of climate change. Canada is warming at two-to-three times the rate of the rest of the world, and "the effects of widespread warming are already evident in many parts of Canada and are projected to intensify in the near future."[69]

Extreme weather events are increasing the exposure and vulnerability of Canadians to the country's changing climate, and though detection and attribution research is still emerging, this line of research can help inform and guide policymakers responsible for designing and implementing long-term adaptation and mitigation strategies for Canada.

ANNEX

ANNEX

TABLE: CATEGORISATION OF ATTRIBUTION STUDIES ACROSS NINE EXTREME WEATHER EVENTS IN CANADA FROM 2013 THROUGH 2018.

EVENT	STUDY	REPORT CONCLUSIONS
FLOODS		
2017 Quebec foods	Teufel et al., (2019) Investigation of the mechanisms leading to the 2017 Montreal flood. Climate Dynamics, 52(7-8), p.4193–4206 - https://link.springer.com/article/10.1007/s00382-018-4375-0	"Event attribution using CRCM5 showed that events such as the heavy April 2017 precipitation accumulation over the ORB are between two and three times as likely to occur in the present-day climate as in the pre-industrial climate. This increase in the risk of heavy precipitation is linked to increased atmospheric moisture due to warmer temperatures in the present-day climate, a direct consequence of anthropogenic emissions, rather than changes in rain-generating mechanisms or circulation patterns."
2014 Saskatchewan and Manitoba floods	Szeto et al., (2015) The 2014 extreme flood on the southeastern Canadian prairies [in "Explaining Extremes of 2014 from a Climate Perspective"]. Bull. Amer. Meteor. Soc., 96 (12) p.S20-S24 - https://journals.ametsoc.org/doi/pdf/10.1175/BAMS-D-15-00110.1	"Results from this study indicate that anthropogenic forcing may have played a role in causing the significant increase in MJ rainfall in the ARB, while the extensive removal of ponds could have amplified the runoff response to the changing climate to substantially enhance the potential for extreme floods such as those in 2011 and 2014."

2013 Alberta floods	Teufel et al., (2017) Investigation of the 2013 Alberta flood from weather and climate perspectives. Climate Dynamics, 48(9–10), p.2881–2899 - https://link.springer.com/article/10.1007/s00382-016-3239-8	"Event attribution, which focuses on the comparison of present-day and pre-industrial climates, indicates a clearly attributable increase in ET for present-day climate in some of the regions that contributed moisture to the event. Similarly, over southern Alberta, 1-day maximum and 3-day precipitation return levels are slightly higher in present-day climate than in pre-industrial climate, suggesting that anthropogenic emissions played a role in the meteorological flood. However, no anthropogenic influence can be detected on the magnitude of the hydrological flood, as runoff generation is complex, and increases in extreme precipitation might be balanced by decreases in snow mass and frozen ground conditions."
WILDFIRES		
2017 British Columbia wildfires	Kirchmeier–Young et al., (2018) Attribution of the Influence of Human–Induced Climate Change on an Extreme Fire Season. Advancing Earth and Space Science.7(1), p.2-10 - https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2018EF001050	"We show over 95% of the probability for the observed maximum temperature anomalies is due to anthropogenic factors, that the event's high fire weather/behaviour metrics were made 2–4 times more likely, and that anthropogenic climate change increased the area burned by a factor of 7–11."
2016 Fort McMurray wildfires	Tett et a., (2016) Anthropogenic forcings and associated changes in fire risk in western North America and Australia during 2015/16 [in "Explaining Extremes of 2016 from a Climate Perspective"]. Bull. Amer. Meteor. Soc., p.S60-S64 - http://www.ametsoc.net/eee/2016/ch12.pdf	"Extreme vapour pressure deficits (VPD) have been associated with enhanced wildfire risk. Using one model, we found for 2015/16 that human influences quintupled the risk of extreme VPD for western North America and increased the risk for extratropical Australia."
2016 Fort McMurray wildfires	Kirchmeier-Young et al., (2017) Attributing extreme fire risk in Western Canada to human emissions. Climatic Change, 144(2), p.365–379 - https://rd.springer.com/article/10.1007%2Fs10584-017-2030-0	"For the majority of these metrics and during the current decade, the combined effect of anthropogenic and natural forcing is estimated to have made extreme fire risk events in the region 1.5 to 6 times as likely compared to a climate that would have been with natural forcings alone."

HEATWAVES		
July 2018 heatwave in Quebec	Vogel et al., (2019) Concurrent 2018 hot extreme across Northern Hemisphere due to human-induced climate change. Earth's Future, in review - https://www.ethz.ch/en/news-and-events/eth-news/news/2019/04/simultaneous-heatwaves-caused-by-anthropogenic-climate-change.html	"Without the climate change that can be explained by human activity, we wouldn't have such a large area being simultaneously affected by heat as we did in 2018," says Vogel.
DROUGHTS		
2015 extreme drought in western Canada	Szeto (2016) The 2015 Extreme Drought in Western Canada [in "Explaining Extremes of 2015 from a Climate Perspective"]. Bull. Amer. Meteor. Soc., 97 (12) p.S42-S46 - https://journals.ametsoc.org/doi/abs/10.1175/BAMS-D-16-0147.1	"Results from this study indicate that ACC likely played a role in causing the warm late-winter temperatures and the associated reduction in snowpack that set the stage for the 2015 drought. On the other hand, there is no detectable evidence that GHG forcing influenced the intensity or the likelihood of occurrence for the strong and persistent upper-air ridge off the west coast that brought the record heat and dryness in MJJ, which escalated the drought to an extreme event. The results thus suggest that the extreme drought was likely an outcome of anthropogenic effect that has increased the occurrence of extreme warm spring temperatures and natural climate variability that caused the persistent upper ridge."

ENDNOTES

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