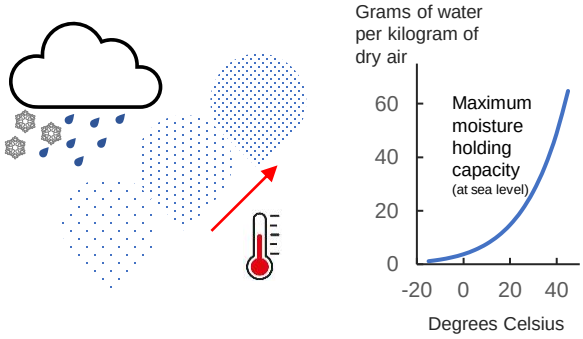
More Intense Precipitation in a Warming World

As global temperatures rise, extreme rainfall and other precipitation events are becoming more common and more intense. The disastrous consequences are also becoming increasingly apparent. A research project within the Global Water Futures program, *Short-Duration Extreme Precipitation in Future Climate*, takes a closer look at these changes.

BY FRANCIS ZWIERS, YANPING LI, AND CHRIS DEBEER

Record-breaking rainfall events triggering flooding, landslides, and debris flows have been seen more frequently in many parts of the world in recent years. These often have severe impacts on vulnerable communities and infrastructure and can have longer term consequences for health and human wellbeing. In Canada, unprecedented rainfall-driven flooding events such as in the Rocky Mountains and Calgary as well as the city Toronto in 2013, and the B.C. lower mainland in 2021 caused an estimated 15 billion dollars of damage, loss of life, and the evacuation of over 120,000 people. Understanding these events, the role of climate change, and how they may change in future is extremely important towards improving disaster warning and informing risk management policies and practices.



More Atmospheric Moisture

Warmer air can hold more moisture—for every 1°C rise in temperature, air can hold about 6-7% more water vapour. More moisture in the atmosphere can lead to more intense rainfall and heavier snowfall when these events occur.

The Coquihalla Highway near Hope, British Columbia was severed by floodwaters and debris flow resulting from record-setting heavy rainfall in November, 2021. It was found that human-caused climate warming increased the probability of this event by roughly 50% (see https://doi.org/10.1016/j.wace.2022.100441).
Photo: THE CANADIAN PRESS/Jonathan Hayward.

▲1.1°C
0.95–1.20°C
90% confidence range

Observed global warming, 1850–1900 to 2011–2020. This is unequivocally linked to increasing greenhouse gas concentrations.

▲6.6%per°C
5.1–8.2%per°C
90% confidence range
Annual maximum precipitation accumulated over 1 day based on stations available globally

Global weather station data show that extreme precipitation has intensified since the 1950's at the rate of 6.6% per 1°C of observed global warming. This is generally consistent with the increase in the atmosphere's moisture holding capacity with warming.

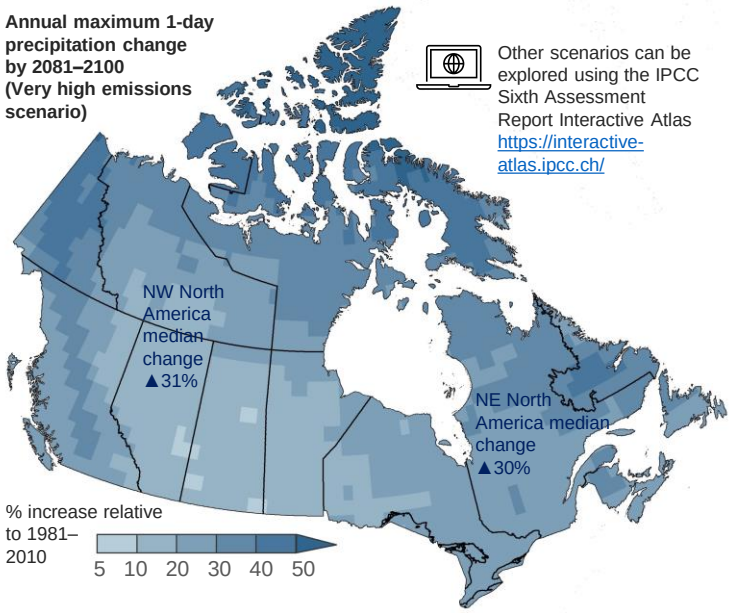
▲66%
▲9.1% **Of trends statically significant (2.5% expected by random chance)**

The majority of global observation stations show increasing trends in extreme precipitation. 1-day extreme events expected once in 20 years in the 1950's now occur 10-30% more frequently due to greenhouse gas induced warming

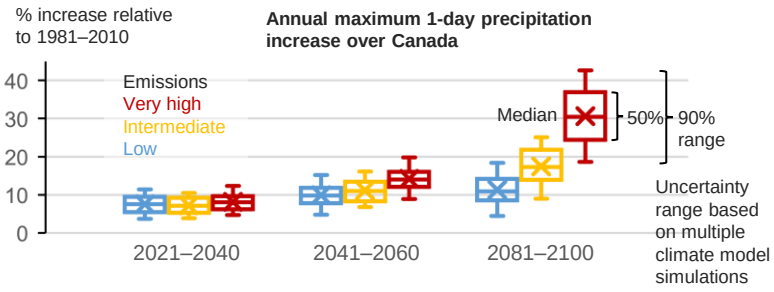
Clear Global Patterns and Trends

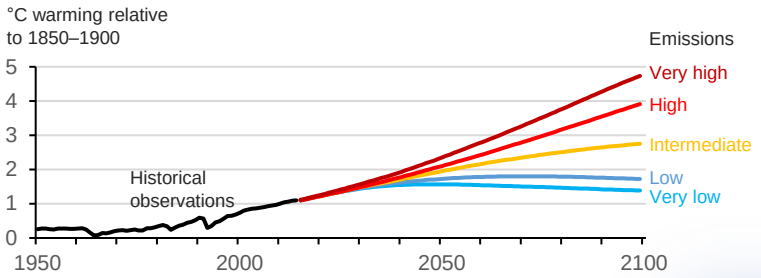
Observations over many continents have shown clear evidence for broad and systematic increases in the intensity of precipitation in recent decades. This is directly linked to human influence on the climate system and increasing atmospheric moisture. It is important to note that local trends may vary to some extent due to variations in wind and weather patterns.

(see https://doi.org/10.1175/JCLI-D-19-0892.1).



Theory and climate models suggest that the intensity of extreme precipitation will increase about 6-7% per degree C of warming. Observations have confirmed this is happening and that the risk of extreme precipitation events has increased. Climate change projections indicate that these risks will become much greater still in the future. In general, rarer and more extreme precipitation events will tend to intensify more rapidly with warming than less extreme events. Globally, pre-industrial 10-year extreme 1-day events are projected to occur about once every six years with 2°C global mean warming, and about once every 3.7 years with 4°C global mean warming. (see https://www.ipcc.ch/report/ar6/wg1/chapter/summary-for-policymakers/)

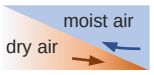




Future occurrence of extreme precipitation
Intergovernmental Panel on Climate Change (IPCC) scenarios of future climate based on greenhouse gas emissions show up to 5°C of global warming is possible by the late-21st century. At higher latitudes, such as northern Canada, this could be much greater. A warmer climate will mean more intense precipitation. What does this mean for Canada? Depending on the scenario, annual maximum 1-day precipitation could increase by 30% or more by the late-21st century.

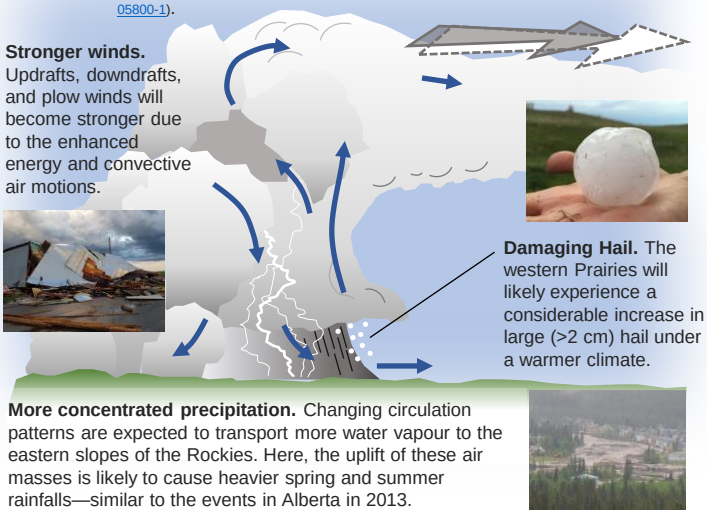
To learn more about this project and its findings, visit gwf.usask.ca/extreme-precipitation

Western Canada Severe Weather Implications
Warmer and more humid air masses favor conditions for more severe thunderstorms. There is high confidence that with the increasing energy available under even modest climate projections, typical storms will become more intense with heavier rainfall.



Stronger "Drylines". Drylines are where moist and dry air masses meet. Their different characteristics and interaction creates unstable conditions, enhancing conditions for severe thunderstorms. A sharper contrast between wet and dry air is expected when these happen. (see https://doi.org/10.1007/s00382-021-05800-1).

Longer storm tracks. Severe storms may last longer, become larger, and travel farther due to the enhanced moisture and heat, which act as 'fuel sources' for the storms. (see https://doi.org/10.1016/j.atmosres.2022.106380)



Stronger winds. Updrafts, downdrafts, and plow winds will become stronger due to the enhanced energy and convective air motions.

Damaging Hail. The western Prairies will likely experience a considerable increase in large (>2 cm) hail under a warmer climate.

More concentrated precipitation. Changing circulation patterns are expected to transport more water vapour to the eastern slopes of the Rockies. Here, the uplift of these air masses is likely to cause heavier spring and summer rainfalls—similar to the events in Alberta in 2013.

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