4. Changes to the Global Hydrological Cycle Driven by Climate Change and the Implications for the Canadian Prairies

The Citizens' Hearings decided to give special attention to how climate change is influencing the global hydrological cycle, given that these changes appear to be having a major influence in Saskatchewan, Alberta and Manitoba. We were fortunate to have Bob Sanford address this topic. Bob is the Director of the Western Watersheds Research Collaborative and EPCOR Chair of the Canadian Partnership Initiative in support of the United Nations "Water for Life" Decade. He noted that hydrologists have been reporting observed changes in the rate and manner in which water moves through the global hydrological cycle for at least a decade. Concern has grown to the point that in 2013 the World Economic Forum ranked the global hydro-climatic crisis 4th out of 50 top global risks of concern, and 2nd in terms of its potential to impact not just the performance, but the survival, of businesses in many sectors of the global economy.

Bob Sanford began by discussing how scientists are increasingly recognizing that polar ice is a thermostat that governs major weather patterns globally. **The concern is that if we lose the refrigerating influence of Arctic sea ice, global temperatures will sky-rocket, with possible releases of methane in the permafrost zone that will further exacerbate warming.**

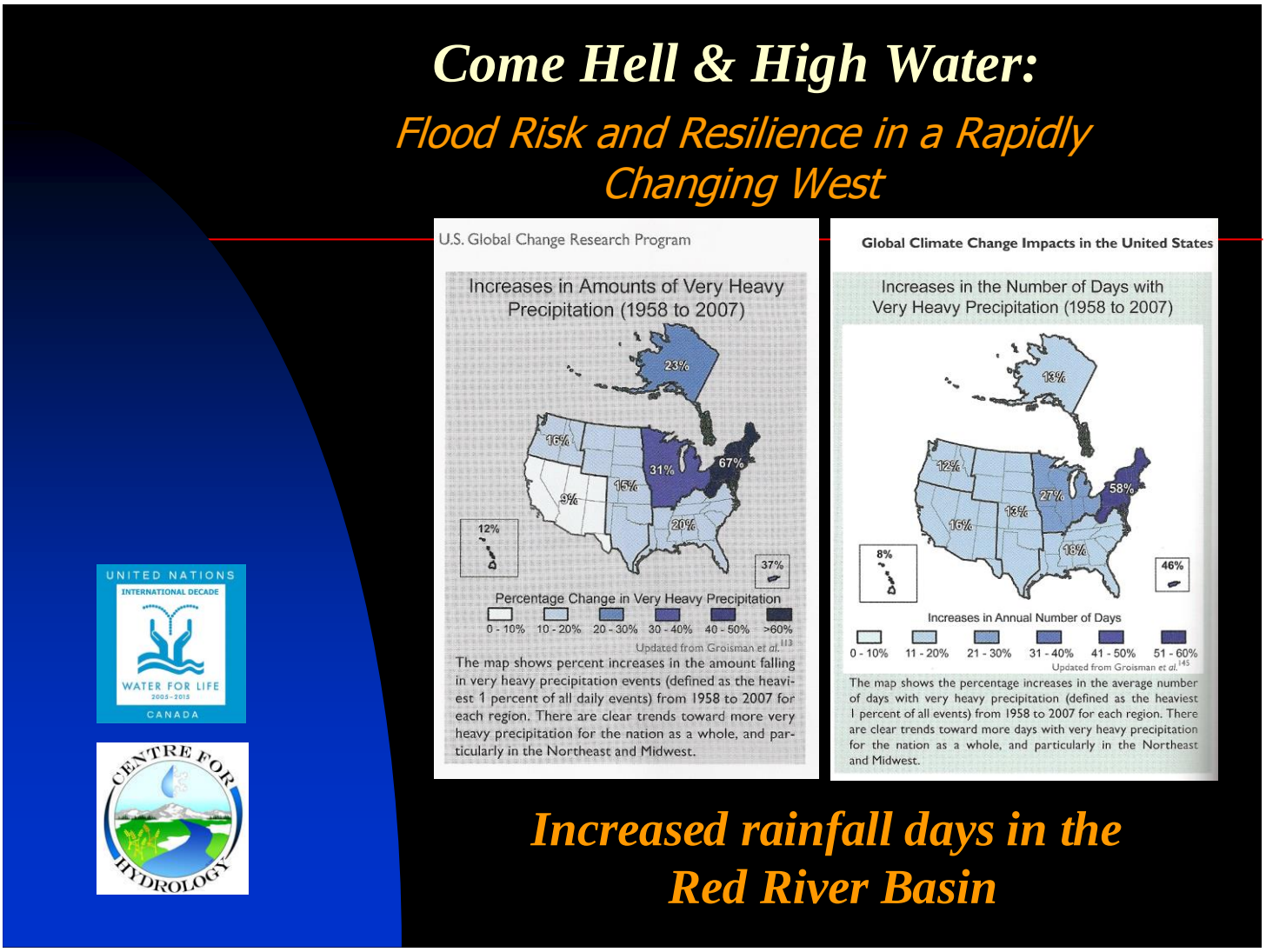
Bob Sanford observed that the loss of Arctic sea ice and the reduction of the extent and duration of snow cover in the Northern Hemisphere are also reducing the temperature gradient between the pole and the tropics. He pointed out that it is this difference in temperature between the polar region and the warmer air to the south that largely defines the behaviour of the Jet Stream. Sanford went on to say:

> "Observations of the Jet Stream have revealed that warmer atmospheric temperatures do not automatically translate into warmer weather. In a uniformly warmer and therefore more turbulent atmosphere, both warm and cold fronts end up and persist in places in the mid-latitudes in which they were not common in the past, often causing floods and droughts of magnitudes we are poorly equipped to manage. What we are seeing in Europe and North America is not so much warming, as the destabilization of historic weather patterns**. People are complaining that the weather is all over the place…What we are now experiencing – more and more widely – are floods, droughts and fires in the same river basins in the same year."**

Bob Sanford argued that atmospheric warming is causing the post-glacial hydrological wealth of Canada to change form. The liquid water is not disappearing; rather it is moving to a different place in the hydrosphere, where it may not be available for our use, but where it can cause a lot of damage.

One of the profound changes taking place is the disappearance of glaciers in the Canadian Rockies, where as many as 300 glaciers disappeared entirely between 1920 and 2005. It appears that trend is now accelerating. A second change is the enormous evaporation from the Great Lakes, where as much as 67 cubic kilometers of water has disappeared from Lake Huron alone. While dredging of the St. Clair River at the mouth of Lake Huron accounts for some of this loss, much of it has simply been lost to the atmosphere, where it becomes available to fuel even more intensive storm events. A third large shift is the changes in precipitation patterns on the Canadian Prairies. Bob Sanford noted that **more prairie rainfall is now being produced by multi-day rainfall events generated by frontal storms, as opposed to shorter term local thunderstorms.** He explained that the changes are negatively affecting water quality, as heavy 'run-off producing' rains wash nutrients, bacteria and toxic contaminants into waterways. He expressed special concern for the future of Lake Winnipeg, which is already plagued by enormous algal blooms, and where increases in the duration and intensity of extreme weather are likely to cause further nutrient loading and contamination.

In a thread similar to the evidence presented about increased precipitation and flooding in parts of Saskatchewan, Bob Sanford noted that precipitation levels have also increased in the Red River Valley, as shown by the slide below.



SLIDE PRESENTED AT THE HEARINGS BY BOB SANFORD

He explained that these **"corridors of intense winds and moist air can be 400-500 kilometres across and thousands of kilometers long. They can carry the equivalent of 7 to 15 times the average daily discharge of the Mississippi River."**

Atmospheric rivers produce flooding of enormous magnitude, and their capacity grows with the ability of a warmer atmosphere to hold more water vapour. Bob cited the 2010 floods that hit Pakistan and Australia as examples. In July and August of 2010 heavy rainfall and flooding left at least six million residents of Pakistan in urgent need of food and clean water, and constituted the biggest humanitarian crisis the country has faced. In December of 2010 flooding hit northeast Australia impacting more than 80 communities with a flood zone that stretched over an area bigger than France and Germany combined.

On the evening of June 20, 2013 Bob Sanford's home town of Canmore, the City of Calgary, and many other communities in southern Alberta experienced a similar type of event. Following very heavy rainfall, Bob recalled:

> "A spectacularly swollen pulse of floodwater flowed downstream from the mountains into the unprepared City of Calgary. **Twenty neighbourhoods had been evacuated, and more than 100,000 people forced from their homes.** But Calgary wasn't the only municipality that was in trouble. Twelve southern Alberta communities had declared states of emergency. Eight communities besides Calgary were under evacuation orders… Flooding was particularly serious in small towns immediately south of Calgary. The flood waters had risen so quickly in High River that residents were trapped in their cars and in their homes, and had to be rescued from their roofs. **The Town of High River was almost completely inundated. Two-thirds of the community flooded and 5000 residents were forced from their homes, including my sister and her husband, who lost everything."**

Soon 1,300 soldiers were sent into flood zones and Premier Alison Redford announced a billion dollars in emergency disaster relief. Bob noted that several lessons can be garnered from Alberta's experience. While the Province of Alberta responded effectively in recovery efforts, the right systems were not in place to predict and manage an event of this magnitude. Moreover, provincial flood maps – based on average flows - were "inaccurate and largely irrelevant". Clearly, the growing threat of extreme weather events means that storm water infrastructure, designed for a more stable climate, needs to be replaced with new systems designed to handle greater extremes. This latter point is reinforced by the US National Academy of Science, which concluded in 2011, that hydrologic stationarity has been lost, and that we can no longer assume that the past will be a guide to the future.

Bob Sanford emphasized **that we have to make disaster resilience a national priority** in Canada, as the United States has done. And he stressed that "when supposed experts tell you that we don't have to worry because the Earth has experienced high carbon dioxide concentrations and warmer temperatures in the past, they don't tell you that during those epochs, extreme weather events lasted for days or even weeks. The problem is not going away." Predicted rises in temperatures of between 2 and 6 degrees Celsius will cause further amplification of the hydrological cycle. Thus, Bob explained that **the flooding in Alberta in 2013 is "nothing compared to what the atmosphere is capable of delivering in the future."**

Alberta was not the only part of the world to experience this kind of flooding in 2013. Central Europe, Colorado and Russia were also hard hit. Bob Sanford described the events that unfolded in Russia as "almost the stuff of science fiction. The weakening of the European Jet Stream caused by reduced snow and sea ice cover led to the creation of a heat dome in Northern Siberia. In July (2013), hundreds of wildfires broke out that were so hot they melted the permafrost below the burning forests creating methane releases from the thawing tundra that added fuel to the fires. Then in early August, in the midst of what was coming to resemble a virtual fire storm, three atmospheric rivers collided over the region, and within four days created a flood that covered a million square kilometers."

Sanford concluded by commenting on the overall threat we face: "Every part of the water cycle flows through, and affects, and is affected by every other part. Changes in the extent and duration of Arctic sea ice and northern snow pack and snow cover have begun to have a cascading effect on weather and climate right down to mid-latitudes. **The loss of hydrologic stationarity is a society game changer**….We now have to be alert to changes in the larger global hydrological cycle, and where possible try to manage and adapt to them…My fear is that the accelerating hydro-climatic effects associated with warming temperatures may have already gotten away on us."

Bob Sanford urged governments and citizens to take action to restore critical aquatic ecosystem function, reverse soil degradation, stop over-applying nutrients that contaminate our rivers and lakes, stop our wastage of water and energy, and stabilize atmospheric temperatures through major reductions in greenhouse gas emissions. These measures would all contribute towards reducing further damage to the global hydrological cycle.