Future water for agriculture

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The world is entering an era of immense water-related threats. Flood and drought directly threaten both people and industry. Floods kill, but also destroy farms and farmland and disrupt agricultural production; droughts threaten agricultural production and the viability of farms and rural communities. The loss of water through drought caused more than $6B in economic damage to the Prairie Provinces in 2001-2002. More generally the value of water to the Canadian economy is estimated at between $7.8B and $22.9B per year in 2011 dollars. We need to protect farmers and food producers against extreme water threats in the face of climate uncertainty and human-induced global change. Canada and much of the world are ill-prepared for this new era of water threats, which has already resulted in intensified floods and droughts, reduced water availability and degraded water quality, costing billions in economic loss and impacting the health of populations.

Why is this and how serious is the problem? Climate warming and human actions are altering precipitation patterns, reducing snowpacks, accelerating glacier melt, intensifying floods, and increasing the risk of droughts, while pollution from population growth and industrialization is degrading water systems. By 2050, six billion people could face water scarcity. Nearly 80 per cent of the world's jobs depend upon having access to an adequate supply of water and water-related services and many of these are in agriculture. Global trade in food and goods, as well as entire communities, industries and nations are at risk. With such unprecedented change, it is clear that the historical patterns of water availability are no longer a reliable guide for the future, and few Canadian industries will feel this as acutely as will agriculture. Adaptation to these water changes will require new science to understand the changing climate, land, agricultural systems, water and their interactions; new computer modeling tools that will precisely capture these interconnected forces and their societal implications; new monitoring systems with greater capacity to warn of critical environmental changes; and more effective mechanisms to translate new scientific knowledge into farm management. This translates into the grand challenge for water science in Canada and globally: "How can we best prepare for and manage water futures in the face of dramatically increasing risks?"

The recently launched Global Water Futures (GWF) is a 7-year $143M project led by the University of Saskatchewan and primarily funded by the federal Canada First Research Excellence Fund, the Province of Saskatchewan, four institutional partners (University of Saskatchewan, University of Waterloo, McMaster University, and Wilfrid Laurier University), and industries. GWF is supported by partners from 18 Canadian universities (388 researchers), eight federal government agencies, 28 provincial government agencies, seven indigenous communities and governments, 34 industrial collaborators, and 45 international research institutions. It will link with large international partners such as UNESCO, the World Climate Research Programme and Future Earth to demonstrate and export Canadian water expertise and technology around the world. It is the largest university-led water research program in the world and reflects the largest research grant to the University of Saskatchewan. With this unprecedented critical mass of expertise, GWF will provide state-of-the art national flood and drought forecasting that national and provincial agencies currently do not have the capacity to provide. In doing so, GWF will transform the way communities, government, and industries such as agriculture prepare for and manage water-related risks in an era of unprecedented change. It will establish Canada as a global leader in water science for cold regions where snow, ice and frozen soils are major controls on water supply and quality. GWF will address the strategic needs of Canada's water dependent economy in adapting to change and managing the risks of uncertain water futures and extreme events.

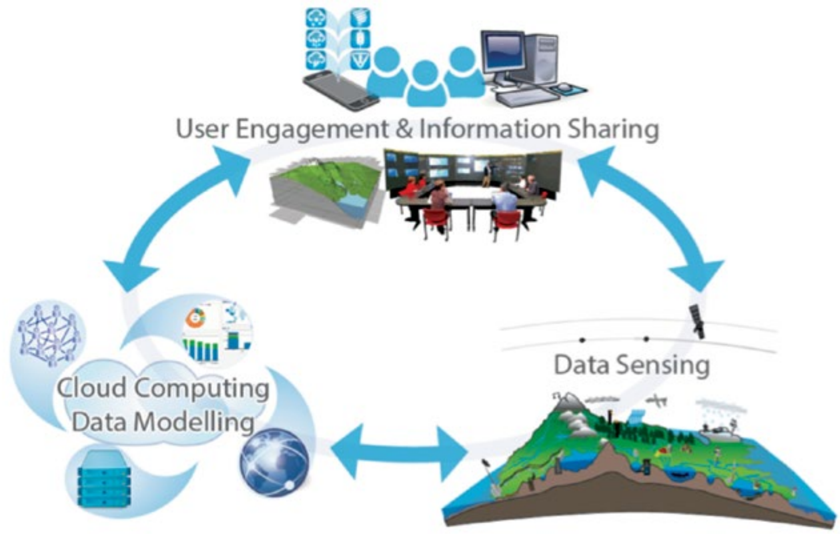
GWF's goal is to deliver risk management solutions – informed by leading-edge water science and supported by innovative decision-making tools – to manage water futures in Canada and other cold regions where global warming is changing landscapes, ecosystems, and the water environment. End-user needs such as those from the farming community will drive strategy and shape our science as we focus on three main goals:

1) Deliver new capability for providing disaster warning to governments, communities and the public, including Canada's first national flood forecasting and seasonal flow forecasting systems, new drought warning capability, and water quality models and monitoring that warn of hazards to health and drinking water supply;

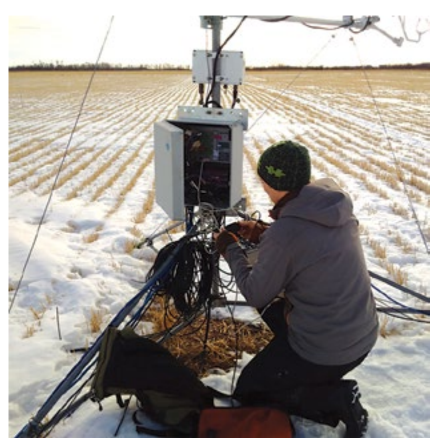
2) Diagnose and predict water futures to deliver improved scenario forecasting of changing climate, landscape and water for the future, with information outputs tailored to the needs of users. This will enable us, for example, to assess risks to agricultural production from changing flood, drought and water quality; and

3) Develop new models, tools and approaches to manage water-related risks to multiple sectors, integrating natural sciences, engineering, social and health sciences to deliver transformative decision-making tools for evidence-based responses to changing water supplies. This will, for example, enable farmers to plan for crop development and improved efficiencies in water and nutrient management while delivering improved productivity and environmental benefits. New models will define changing risk from floods and drought, and allow end-users to plan farm investment and agricultural land management to manage future risk.

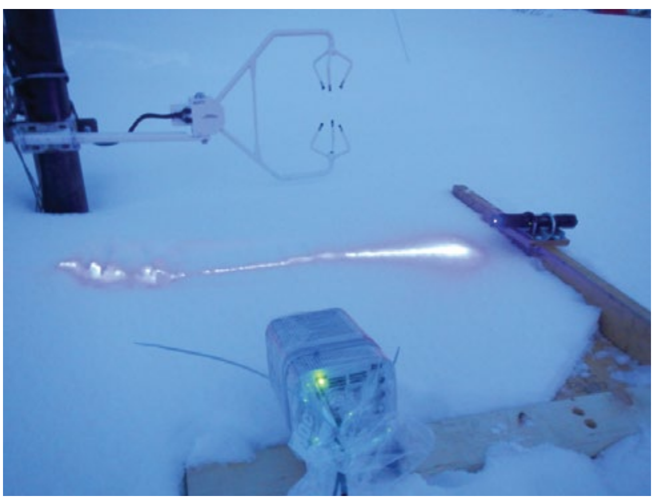
What sort of science will GWF build upon? Over 50 years of field research at the University of Saskatchewan we have found that the spring snowmelt provides over 80 per cent of annual runoff in the Canadian Prairies and an important replenishment to soil moisture, and while the snowmelt rate is governed by spring energy from the sun and warm air, how quickly the snow-covered area over a field declines is governed by how much the snow has been redistributed by winter



How Global Water Futures will use new information from remote sensing by drones and satellites and new water and snow sensors to create big data for water. This data will be analysed in large cloud-based computer networks to predict water futures, forecast water supply, quality and soil moisture and then shared with users in agriculture through websites and smartphone apps.

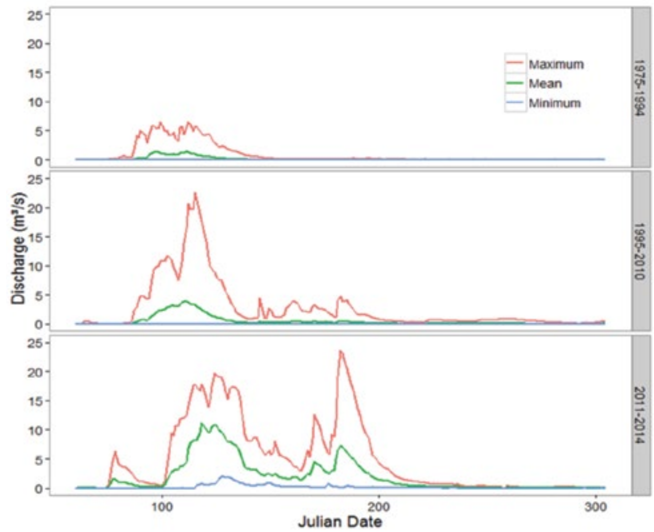


Measuring atmospheric energy for snowmelt and melt rates in a cultivated field near Rosthern, Saskatchewan blowing snow storms. We developed a blowing snow gauge device using an LED and photodetector in the 1980s and found that horizontal blowing snow transport to drifts in shelterbelts, ditches, yards, coulees and sloughs often exceeded prairie agricultural runoff by overland flow in spring, that blowing snow transport did not heed watershed drainage divides, and that snow could be managed by retaining tall crop stubble, leave strips or wooded shelterbelts, and that in-transit sublimation (evaporation of snow) could return over one-third of seasonal snowfall to the atmosphere from summer-fallowed fields, reducing snowmelt volumes available for infiltrating into soils for spring crops. More recently we have developed an acoustic snow water equivalent gauge that sends a soundwave through the snowpack and can measure the snowpack's depth, density, wetness and temperature. And we have deployed fixed wing drones to measure prairie field snow depth and its variability using photogrammetry. Deployment of these new instruments will help farmers manage their snow by knowing how much is there, where it is and how ready it is to melt.



Laser-based measurement of blowing snow using high speed photography to track individual blowing snow particles as they cross a field.

In the Canadian Prairies, computer-based water prediction models have been written, based on studies of blowing snow, snowmelt, evaporation and crop transpiration, infiltration to frozen and unfrozen soils under various tillage options. A comprehensive computer model of prairie hydrology including tillage, snow management and wetland dynamics has been developed and used to evaluate the impact of cultivation changes and wetland drainage in Smith Creek, Saskatchewan. Cultivation changes had modest impacts on streamflow but wetland drainage or restoration substantially altered discharge rates, peak flows and long-term flow volumes. Analysis of weather and streamflow records show that there is more rainfall and less snowfall and dramatically increasing multiple-day rainfall events that have led to unprecedented widespread flooding in summer. Recent research is seeking to understand the role of wetland drainage and climate change in affecting the widespread prairie flooding of 2011 and 2014 and in calculating the export of Nitrogen and Phosphorous from fields as a function of climate, weather, soil type, cultivation and other agricultural practices. Results suggest that the shift to increasing rainfall is one factor causing greater nutrient exports from prairie fields.



The changing hydrology of Smith Creek, Saskatchewan. Streamflow discharge measurements from January 1st show a dramatic change from 1975 to 2014.

Where will we be in seven years? By 2023, GWF will have delivered unprecedented scientific understanding, vast water data, new water monitoring technologies, and sophisticated computer modeling tools with results provided to the farm gate to enable Canadian producers to have reliable water and soil moisture forecasts in response to drought, flood, and water quality threats. We hope that these new sources of information will help farmers to better manage their productivity and agricultural runoff and so help preserve the water quality of prairie lakes and rivers while increasing food production. GWF will provide evidence-based solutions to improve disaster warning, predict water futures (such as national flood forecasting), and forecast future climate impacts which will help keep agriculture more productive and help producers make good choices as our climate shifts.

We will be consulting with the farming community about your water information needs and how we might address these and on the results of our studies that are relevant to agriculture. FFT

You can find more about Global Water Futures at our website www.globalwaterfutures.ca or www.usask.ca/gwf.