Second Annual Open Science Meeting of the Global Water Futures RHP

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Much of the world's population is dependent upon water from cold regions, which are at the forefront of global warming and undergoing rapid change and an increase in the occurrence of extreme events. Finding solutions for how to best forecast, prepare for, and manage water futures in the face of dramatically increasing risk is a global imperative. The Global Water Futures (GWF; *www.globalwaterfutures.ca*) Program is a Canadian-led GEWEX Regional Hydroclimate Project (RHP) that funds over 165 professors from 15 Canadian Universities in 45 GWF projects and core teams, and works with hundreds of partners from across Canada and internationally. The overarching goal of GWF is to deliver risk management solutions developed from leading-edge water science and supported by innovative decision-making tools to manage water futures in Canada and other cold regions. The focus of GWF is on: (1) improving disaster warning and developing forecasting capacity to predict the risk and severity of extreme events; (2) predicting water futures through the use of Big Data and improved numerical models to assess changes in human/natural land and water systems; and (3) informing adaptation to change and risk management through governance mechanisms, management strategies, and policy tools and guidance.

GWF focuses on major river basins in Canada and the United States, and key ecological, climatological, and physiographic regions (see map below) that are representative of the scientific and societal issues faced globally and especially within cold regions where snow, ice, and frozen soils dominate water processes. Canadian landscapes, ecosystems and the water environment are at the forefront of climate change. River basins are challenged by increasing water demands, high nutrient loads, warming temperatures, altered patterns of rainfall, snowfall, snowmelt and freeze-thaw cycling, glacier loss and permafrost thaw, and changes in river flow regimes. Much of Canada is warming 2-3 times faster than the rest of the world, which is leading to profound changes to its cold region hydrology, water management and aquatic ecosystems. Climate change has increased the severity and frequency of extreme events, leading Canada to experience an unprec-

***Figure 1**. Map of the GWF Canadian RHP geographic study domain across Canada and parts of the USA. GWF focuses on eight major river basins spanning across the country. Core observational, and climate and hydrological modeling components of the program focus on all of these basins.*

edented series of disasters in recent years—2001–2004 Prairie droughts, 2013 Alberta/BC floods, 2013 Toronto flood, 2016 Fort McMurray wildfire, 2017 BC and New Brunswick floods, 2017-2018 British Columbia fires, and 2016–2019 flooding in Quebec, Ontario and New Brunswick. These disasters have caused damages approaching CDN$30B. As a result, federal disaster payments are overspent by an order of magnitude. In addition to global warming-induced changes, water management also impacts remote river basins used for hydroelectric power generation. Infrastructure developments such as dams, hydroelectric generation, diversions and irrigation networks, along with industrialization and urbanization, have altered the natural water cycle. Pollution from population growth, industrialization, and agriculture has degraded water quality in many regions resulting in hundreds of drinking water advisories for rural Indigenous communities in Canada. The implications of human-driven changes and their interactions with the natural environment have not been adequately understood and characterized.

GWF is developing a number of important international linkages and expanding its scientific activities beyond Canada to address these issues globally. As a GEWEX RHP, the GWF is also an expanded follow-on project from the Changing Cold Regions Network RHP (CCRN; 2013–2018; *www.ccrnetwork.ca*) and the Mackenzie GEWEX Study (MAGS; 1996–2005 *http://www.usask.ca/geography/MAGS/index_e.htm*). GWF closely interacts with the International Network for Alpine Research Catchment Hydrology (INARCH; *http://www.usask.ca/inarch/*), a GEWEX crosscutting project. In May 2018, GWF helped host the 8th GEWEX Open Science Conference in Canmore, AB, Canada—the first time the GEWEX Conference was held in Canada. A memorandum of understanding has been signed between GWF and the Chinese Academy of Sciences and the Third/Three Pole Environment Initiative—a proposed RHP under GEWEX. Other key linkages include the Sustainable Water Futures Programme of Future Earth and the United Nations Educational, Scientific, and Cultural Organization (UNESCO) International Hydrological Programme (IHP), and the UN through its International Water Action Decade: Water for Sustainable Development, 2018–2028. GWF has formal linkages to the World Meteorological Organization (WMO) and is co-leading a *High Mountain Summit* to be held in Geneva, Switzerland in late October 2019. Major areas of international collaboration and support with GWF involve a focus on high mountain and cold regions, and GWF is currently developing plans and allocating funds for a planetary water prediction (PWP) effort with a focus on these regions globally. This involves collaboration with countries in the Americas, Asia and Europe, to develop, support, test, and apply coupled climate–hydrology–water quality–water management models globally with an emphasis on river basins where high mountain water supplies feed lowland water demands and ecosystem needs.

Participants of the 2nd GWF Annual Open Science Meeting take part in a Round Dance to mark the end of the day of Indigenous cultural learning at Wanuskewin Heritage Park on 15 May 2019. Photo credit: Wanuskewin Heritage Park

GWF recently held its Second Annual Open Science Meeting in Saskatoon, which was organized and hosted by the University of Saskatchewan (USask) and Wanuskewin Heritage Park (*https://wanuskewin.com/*). With over 500 attending, 282 poster and oral presentations and six keynote plenary presentations, this was the largest water science meeting ever held in Canada. The meeting was open to all members and affiliates of the GWF Program, its extended community of partners, and others wanting to connect. It included many exciting, informative, and unique events and activities meant to review and better link together GWF's technical and scientific advancements, while promoting further development and training of early career researchers, Indigenization and decolonization of GWF in the spirit of reconciliation, and engagement with partners and stakeholders.

The meeting was notable and unique for including significant contributions throughout from GWF Indigenous community co-led water research projects across Canada, and an Indigenous cultural sharing and learning exchange held at Wanuskewin Heritage Park. This involved local community Elders and members, Wanuskewin interpretive staff, and the Office of Indigenous Initiatives at USask, who shared knowledge of the history, culture, spirituality and worldview of the Indigenous Peoples of the region. Attendees divided into groups and moved through various activities, including a Powwow with traditional dancers and drummers; a tour of ongoing archaeological excavations at the Park; sampling of Walleye—a traditional food for the Cree People in the Saskatchewan River Delta region—and stories of the changing environment of the Delta; knowledge exchange on Bison hide processing and its cultural importance; and a showcasing of Indigenous art, crafts, medicines and ceremonial artifacts. The meeting also included a keynote presentation from the Chief of the Federation of Sovereign Indigenous Nations—a Treaty and Inherent Rights organization that represents 74 First Nations, and over 160,000 Indigenous People—on water issues facing Indigenous Nations.

Parallel thematic sessions focused on: (i) climate and hydrology, (ii) human dimensions and hydro-economics, (iii) ecosystems and water quality, and (iv) modeling advancements. These sessions revealed the remarkable range and quality of research being undertaken across GWF and fostered collaboration, synthe-

sis and discussions on research impact with partners and users. Plenary sessions featured keynote talks by high-level scientists and leaders on key issues relevant to GWF, linking with each of the themes covered in parallel sessions. Plenaries also included highlights of some of the research accomplishments from the GWF Program, and provided an opportunity for several rounds of lightning talks—2-minute short summaries to draw attention to individual posters. A banquet plenary by David Grimes, President of WMO, provided a valuable insight into international atmospheric and hydrological initiatives. A poster and networking session included over 200 posters and provided excellent opportunities for fostering discussion. Achievements noted at the meeting were the outcomes of the first national flow-forecasting workshop and progress towards a national water forecasting system; a national multi-scale, multi-physics coupled meteorological-hydrological-water management-water quality modeling system. Prototypes of the system are providing physically based river basin predictions that include the impact of climate and land use change and water management, and include full representation of the cryosphere. Modeling components, such as water quality and hydro-economics, are showing great promise for future coupling.

The meeting provided many opportunities for students and young professionals, and was an excellent venue for networking. Prior to the meeting, there was a one-day series of professional development workshops for building writing skills and strengthening communication and knowledge mobilization abilities. The GWF Young Professionals (YP) organization also had their annual meeting and networking social to highlight the year of YP activities and introduce new executives into the membership.

On the evening prior to the meeting, a public outreach event was held at the Roxy Theatre in Saskatoon, which included an overview of the GWF Program, a keynote presentation on existing and emerging water issues, and the challenges facing the Canadian Prairie Provinces. In addition, there was a panel discussion with question and answer forum that included a diverse group of water experts who shared their knowledge and expertise. This was a well-attended and positive transdisciplinary event, and provided an opportunity to showcase GWF and what it is doing in response to global water challenges and local societal concerns.

Moving forward there are high expectations of the GWF Program and many ambitious goals to achieve. This meeting, in general, showed that our program is largely on track, with a tremendous amount of energy and excitement for the delivery of new results and the many significant advancements being accomplished. More information on the meeting, including a list of presentations and abstracts, and photographs from the various events is available on the GWF website (*https://gwf.usask.ca/news-events/meetings.php*). We look forward to our 2020 Annual Open Science Meeting, which will be jointly hosted by the University of Waterloo and Wilfrid Laurier University in Waterloo, Ontario next spring. This will be open to all who wish to connect with GWF. Please see our website (*www.globalwaterfutures.ca*) and Twitter (@GWFutures) for more information or contact us if you would like to become involved with the program.

NOAA/OAR Bedrock-to-Boundary Layer (B2B) Workshop

Boulder, Colorado, USA
23–24 April 2019

Kirsten Findell
National Oceanic and Atmospheric Administration (NOAA) Geophysical Fluid Dynamics Laboratory (GFDL); Global Land/Atmosphere System Study (GLASS) Panel Co-Chair

About 30 NOAA scientists attended the NOAA/Oceanic and Atmospheric Research (OAR) sponsored Bedrock-to-Boundary Layer (B2B) Workshop. The workshop concept emerged out of the recognition that the broad set of scientific problems around observing and modeling land-atmosphere interactions is larger than any one NOAA laboratory can tackle. The workshop co-organizers, Dave Turner, Earth System Research Laboratory (ESRL)/Global Systems Division (GSD), and Tilden Meyers, Air Resource Laboratory (ARL)/Atmospheric Turbulence and Diffusion Division (ATDD), believe that the collective expertise, wisdom, and observational and modeling toolkits distributed across NOAA labs could give the agency the ability to make great strides in the field, if done collaboratively. Such efforts could lead to improvements in process understanding that could translate into improved modeling and forecasting capabilities.

NOAA representatives from GFDL, the National Centers for Environmental Prediction (NCEP) Environmental Modeling Center (EMC), ARL/ATDD, the National Severe Storms Laboratory, the Great Lakes Environmental Research Laboratory (GLERL), and the four ESRL divisions [Global Modeling Division (GMD), Physical Sciences Division (PSD), Chemical Science Division (CSD), and GSD] were present. Two scientists from the National Environmental Satellite, Data, and Information Service (NESDIS) attended and shared their perspectives on satellite resources relevant to land and the planetary boundary layer that might be beneficial to this community. Jin Huang from the Climate Program Office (CPO) and Mark Vincent and Jordan Dale from the Office of Weather and Air Quality (OWAQ) also attended.

Objectives of the B2B Project include: connect members of the broader NOAA/OAR community who are working on issues related to land-atmosphere interactions; establish communications between observationalists and modelers to help both groups understand the needs of the other; and prepare a vision for a NOAA-driven field campaign at a series of locations in different climatological regimes that would be "shovel-ready" should funding opportunities become available.

Follow-up phone calls with the workshop attendees are expected, ultimately leading to a white paper detailing "A Multi-Lab Integrated Observation and Modeling Approach to Understanding Land-Atmosphere Interactions: A Bedrock-to-Boundary Layer (B2B) Approach" to be shared with OAR program managers and lab directors. There is clearly a lot of overlap between the research objectives of this group and those of the GEWEX/GLASS community, although the focus of the B2B group is skewed towards shorter time-scales than that of the GLASS panel. We look forward to communication and collaboration between the GLASS and B2B communities.