Global Water Futures 2021 Operations Team Meeting – Project Reporting Template

Instructions: All GWF projects are asked to provide a summary update on their activities and accomplishments in preparation for the upcoming Operations Team meeting. **Please submit these by email to chris.debeer@usask.ca by no later than December 2.** These will be used to help guide discussions and breakout synthesis activities and will be made generally accessible on our website in advance of the meeting.

Project Name:	Mountain Water Futures

Our major accomplishments to date are:

Surface/Groundwater Interactions

- Conducted detailed field studies at several alpine catchments in the Canadian Rockies to identify major types of aquifers their roles in sustaining the baseflow of mountain rivers. Developed a conceptual framework of alpine hydrogeology
- Investigated the importance of spatial distribution of alpine aquifer units and demonstrated the special significance of moraine as a gate keeper of groundwater discharge in this catchment
- Investigated the influence of surface water – groundwater interaction on the thermal regime of the headwater streams in various alpine environments and evaluated the efficacy of a stream energy balance model in representing the interaction
- Established new research watersheds established along the Dempster Highway

Vegetation and Wetlands

- Quantified the hydrological connectivity to hillslopes, underlying alluvial aquifers and buried alluvial fans, and their role in runoff generation
- Utilized Beaver Dam Analogues (stream restoration structures) to enhance stream habitat and support threatened coldwater fish thermally regulating streams.
- Revealed influence of beaver dam structure on flood attenuation and water storage capacity.
- Identified unique storage profile of mountain soil peatlands due to their geomorphically dynamic environment.
- Identified rapid shrub expansion in subarctic through repeat LiDAR measurements with field validation.
- Clarified the role of different vegetation units on evapotranspiration and energy partitioning in subarctic mountainous catchments.

Cryosphere

- New observations at Conrad Glacier site in Purcell Mountains for alpine thermal regime measurements
- Completed modelling of the effect of climate change along with deglaciation on Canadian Rockies. Using WRF-PGW for climate change in non-glaciated basins we predict a substantial decrease in snowfall, sublimation and peak snowpack, advance in melt timing, and an increase in rainfall, ET and annual streamflow. Using the same climate forcing for glaciated basins, predicted a decrease in snowfall, blowing snow sublimation, peak snowpack and annual streamflow volume, advance in melt timing, loss of ice and firn melt contributions, and an increase in rainfall.
- Special analysis of wildfires and glacier melt on the Athabasca Glacier showed for the 2015-2020 melt season that upwind wildfire activity influenced surface glacier melt through both a decrease in the surface albedo from deposition of soot and ash on the glacier and through the impact of smoke on atmospheric conditions above the glacier.

Climate

- Development of a climatology of landfalling atmospheric rivers along the BC and southeastern Alaska coast and quantification of their contributions to annual precipitation and streamflow in the region.
- Showed that some locations in the Coast Mountains, such as Terrace, have some of the highest occurrences of temperatures near 0°C in the country and these are often accompanied with precipitation.
- Examined the occurrence of precipitation transition regions in the current and future climate using CONUS I information and found that occurrences and average elevations increase more in interior regions than near the coast under PGW conditions.
- Collected precipitation amount and type information in relation to documented atmospheric rivers in the Nechako watershed during September and October 2021.

Model Development and Testing

- Implementation of the VIC-GL model to the 51,600 km^2 Stikine Watershed of northwestern BC in addition to two of its primary sub-basins, the Iskut and Tuya river basins.
- Completion of VIC-GL historical simulations for the Tuya and Iskut river basins without glacier dynamics.
- Analyses of model output vs observations trends and variability across the Stikine Watershed.
- Application and development of CHM in Canadian Rockies

Our current activities are:

Surface/Groundwater Interactions

- Conducting a systematic study of permafrost distribution and the critical factors controlling the distribution in the Canadian Rockies.
- Conducting a field study of an alpine karst system to advance our understanding of karst aquifers in the Canadian Rockies
- Developing a GIS-based tool to map the extent and distribution of alpine sedimentary aquifers and a method to represent the groundwater storage-discharge characteristics of these aquifers using relatively simple mathematical algorithm
- Developing a 3D hydrogeological model of a permafrost-influenced alpine basin
- evaluate how freezing parameters affect groundwater dynamics in a cryohydrogeologic model
- applying CRHM to a site in the High Peruvian Andes
- Identifying the influence of frozen ground and geomorphic setting on the storage and release of water in cold alpine catchments.
- Evaluation of thermal regimes in cold mountainous rivers.

Wetlands and Vegetation

- Using dendrochronology and wood anatomy analysis to test correlations between wood anatomy and growth of shrubs versus snowpack across long-term monitoring snow stations at various elevations.
- Examine ET relative to sub-surface processes governing surface water storage and groundwater-surface-water interactions, and the development of ground frost in relation to snow depth and Chinook activity.
- Understand the impact of winter conditions on mountain peatland soil frost development and carbon flux.
- Evaluate beaver dam impacts on peatland ET.
- Advance the inclusion of beaver dams in catchment hydrologic models
- Assessment of the impacts of the summer 2021 heat dome with several MWF and GWF collaborators

- Utilization of stable isotopes to identify plant water sources in alpine catchments.
- Investigation of wetland hydrology and type in cold alpine catchments.

Cryosphere

- Contined measurements of bedrock/snowpack temperatures, detailed thermal profiles of snowpacks at two alpine locations, and measurements of thermal conditions in and around alpine vegetation
- Continued glacial investigations in the Canadian Rockies

Climate

- Characterizing rain-snow transitions in the southern Canadian Rockies using CONUS I simulations.
- Carrying out additional studies on atmospheric rivers including the extreme mid-November 2021 event in BC.
- Carrying out a background observational and CONUS II climatology of near-0°C conditions in the Terrace area.
- Collecting precipitation characteristics at the surface and aloft to document near-0°C conditions in Terrace, BC during November-December 2021.

Model Development and Testing

- Finalizing VIC-GL simulations for the Iskut River Basin using VIC-GL model coupled to a Regional Glacier Modeling (RGM).
- Analyzing the impact of glacier dynamics on streamflow generation.
- Comparing the simulation outputs to contrast changes in the glacierized (Iskut) versus non-glacierized (Tuya) sub-basins to quantify the contribution of glacier melt to river flows.
- Preparation of a manuscript reporting on the VIC-GL simulations.
- Ongoing CHM model testing and development.

The main accomplishments expected by the end of the project are:

Surface/Groundwater Interactions

- GIS-based tools to map alpine aquifers for medium-size (< 2000 km^2) high-elevation watersheds
- Simple mathematical algorithms to represent groundwater storage-discharge characteristics of alpine aquifers.
- Methodology to estimate the probability of alpine permafrost in the Canadian Rockies based on climate, topography, and surficial covers.
- Improved understanding of alpine karst aquifers in the Canadian Rockies
- Improved understanding of how groundwater (and groundwater-surface water interactions) contributes to streamflow generation in mountain environments
- Quantify the hydrological connectivity to hillslopes, underlying alluvial aquifers and buried alluvial fans, and their role in runoff generation
- Evaluate drivers of long-term water balances in select mountainous catchments.

Wetlands and Vegetation

- Quantify importance of shoulder season ET from sub-alpine forests, and identify dominant controls.
- Identify influence of vegetation change on alpine hydrology.

Cryosphere

- Improved understanding of cryosphere change on coupled climate-hydrological systems

Model Development and Testing

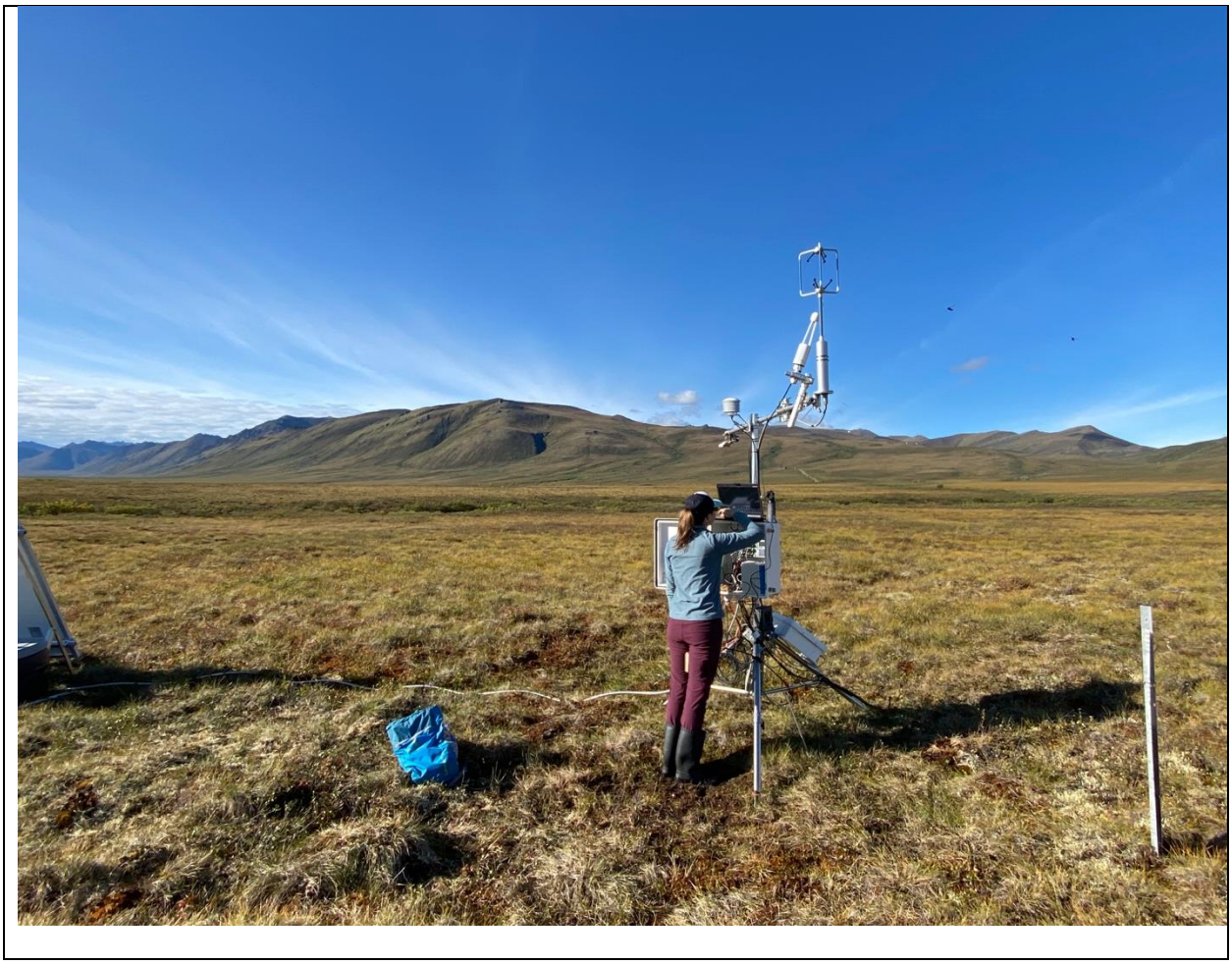
- Completion of the VIC-GL simulations for the Stikine River Basin.

- Completion of a manuscript reporting in the changing contribution of snow and glacier melt to streamflow generation in the Stikine watershed.
- Archiving in a public data repository of VIC-GL simulation output.
- Advancement of CHM development.

Climate

- Better understanding of changes in rain-snow transitions across western Canada in warmer climate conditions.
- Better understanding of AR contributions to hydrological extremes, floods and other hazards in BC including the fall 2021 active storm season.
- Determination of near-0°C conditions at Terrace and nearby regions and expected changes using observational datasets and CONUS II information.

Here is a key visual from the project (figure, photo, table, graph, etc.)

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