SEARCH TERM: Hydrological (and synonyms) – 13 projects

Southern Forest Water Futures

- Development of coupled hydrologic and carbon cycle model (MESH-CTEM) to study coupled water and carbon cycle processes as watershed scales under different climate change scenarios.
- Provision of long-term high-quality data of water, carbon and energy flux, meteorological, hydrological and biometric data sets in different-age and species of southern temperate forests for research and model development by research from Canada and across the world
- Collaboration with the GWF Co-creation of indigenous water quality tools and ecosystem health group to conduct modelling studies at McKenzie Creek to explore the impacts of climate change on hydrological processes and water resources in the Six Nations Community.
- We collaborate with the GWF Co-creation of indigenous water quality tools and ecosystem health project team members for climate change and hydrologic studies in the Six Nations Community.
- We are working on the developing and testing MESH-CLASSIC model to conduct water and carbon cycle studies in selected watershed across Canada in collaboration with researchers from Environment and Climate Change Canada and Natural Resources Canada.
- Improved knowledge of hydrologic and carbon exchange processes and their coupling in Southern Canadian Forests.
- Well tested and improved coupled hydrologic and biogeochemical model (MESH-CLASSIC) for application and research as watershed scale and explore impacts of climate change.
- High quality water, carbon and energy flux, meteorological, hydrological and biometric data sets for research and model development by research from Canada and across the world

Agriculture Water Futures (5 mentions)

- Integration of water quality components into hydrological models
- Integration of water quality components into hydro-economic models
- Inclusion of human behaviours in hydrological models
- Continuing to improve inclusion of crops and water quality in hydrological models
- Inclusion of both crop water use and water quality and their driving factors into hydrological models
- Improved understanding of farmer behaviours and economic choices in the adoption of management practices and the inclusion of coupled human-natural systems (CHANS) into hydrological models

Boreal Water Futures 2

- Completion of parameterization and testing of the Peatland Hydrological Impacts model
- Publication in International Journal of Wildland Fire using multi-criteria decision analysis based on hydrological and wildfire expert opinion to estimate peat fire risk in Alberta's Boreal Plains
- Model output analysis of the Peatland Hydrological Impacts model run under steady state conditions

- Testing the coupling of the Peatland Hydrological Impacts model with both the PSI (smouldering) and CHI (carbon) sub-models
- Technical paper on the importance of peat properties and hydrologic feedbacks using the model out from the Peatland Hydrological Impacts model

Core: Water Resources Management Modelling

- Development of generic reservoir/irrigation models for hydrologic models (A Tefs, F Yassin)
- Publications: https://doi.org/10.1016/j.envsoft.2021.105025, https://doi.org/10.5194/hess-2019-7
- Integration of lakes, reservoirs, irrigation and withdrawals in land surface and hydrologic models
- Comparison of technologies for modelling water resource management:
    - Network routing products, hydrologic models and IWRM models
- Production of climate change and renaturalized scenarios of hydrology to assess with/without regulation and climate change impacts

Integrated Modelling Program for Canada

- **Improved hydrological land-surface modelling** (Dr. Pomeroy's team w/Core Modelling): developed and evaluated a 2-D water flow through snow model to advance both the physical understanding of and ability to simulate water flow through snowpacks as well as a 3-D blowing snow model that reduces the computational costs of accounting for the impact of blowing snow on snow water equivalent and snowmelt. The team also used the Cold Regions Hydrological Model to evaluate the response of snow and hydrological regimes to climate warming, with results showing a generalized decoupling of mountain river hydrology from headwater snowpack regimes.
- **Socio-hydrology and understanding societal response to policy change in water sector** (Drs. Razavi & Elshorbagy's team): Developed a socio-hydrologic, agent-based model to characterize the coupled water-social behavior in the farming sector in response to polices around modernizing traditional irrigation systems. The geographical focus of this work has been on the Bow River Basin, which is a sub-basin of South Saskatchewan River Basin in Alberta. A particular focus has been on human adaption to drought and a possible emergence of the "Rebound Phenomenon" and its implication in this sub-basin.
- **Ecological modelling** (Drs. Jardine & Strickerts' teams): naturalized daily and future flows from MESH (15 climate scenarios, 3 time periods) were used to produce naturalized flow presumptive standards (sustainable boundaries) for 28 sites in Alberta, five sites in Saskatchewan, and two sites in Manitoba. Ecological performance indicators were developed, including percent deviation from natural flow and Indicators of Hydrologic Alteration (IHA) variables.
- **Integration of next-generation hydrological and land surface models to address changing cold region processes**:
    - Detailed statistical analysis based on the available in situ and gridded observation data, as well as CMIP6 projections; comparison between observation and projections. Downscaled CMIP6 precipitation projections for target regions alone with quality assessment of the downscaled products.
    - Complete pan-Canadian high resolution (4-km) atmospheric modelling of historical climate and future warming, the CONUS II simulation; post-processed WRF output; sensitivity test of land–atmosphere feedbacks using existing coupled atmosphere - land surface model. Conduct inter-model comparisons with the ECCC MESH/CLASS modelling system for cold region land surface schemes by collaborating with the core modeling and the ECCC MESH groups. Conduct scenario runs for the

assessment of land–atmosphere feedbacks using WRF-MESH/CLASS coupled modeling system to provide additional context of model and scenario uncertainty.

- **Integrating river ice processes into hydrological modelling for improved operation and flood forecasting**:
  - Implement a validated MESH-GeoSpace-RIVICE natural and regulated river systems in a platform which allows data streaming and flood warning issuances (Saint John River).
- **Hydrologic model inter-comparison and multi-model analysis for improved prediction:**
  - Apply models in regulated basins with streamflow and process outputs to assess model set up accuracy and performance in representing human impacts in the Nelson-Churchill river basin.

Warming Estuaries, Closing Gates

- **Journal publication** (three others in prep for this project): KarisAllen J, Kurylyk BL. 2021. Drone-based characterization of intertidal spring cold-water plume dynamics, Hydrological Processes (HPEye), 35(6) e14258, DOI: 10.1002/hyp.14258

- **Five journal manuscripts/publications** – 1 on inter-tidal spring temperature dynamics (already published in *HP*), 1 on coastal groundwater warming and impacts to groundwater-dependent coastal ecosystems (in prep, led by MASc student J. KarisAllen – to be submitted to *HESS*), one on groundwater temperature patterns in coastal regions as measured in provincial observation well networks (in prep, led by PhD student K. Smith – to be submitted to *HESS*), 1 on estuary temperature modeling under climate change scenarios (in prep, led by PhD student A. Zeighami – to be submitted to *WRR*), 1 on drone vs. fiber-optic DTS vs. loggers ("what do we miss from the air", led by PhD student K. Smith – to be submitted to a hydrology like *HP* or environmental technology journal like *ES&T*). We are also considering a sixth paper on coastal storms and the impacts to thermally stratified lagoons.

- New datasets from five coastal watersheds – including water temperature at all sites and hydrology/weather data at selected sites (all under DMP).

Managing Urban Eutrophication Risks

WP1: watershed hydrology and water quality modeling (*Main objective:* Predict the spatially distributed fluxes and chemical speciation of phosphorus (P) supplied to the littoral zone of Western Lake Ontario (WLO) littoral zone by streamflow and stormwater outflow)

- Modelled hydrology and total suspended sediment (TSS) transport in two sewersheds in Ajax with the PCSWMM model:

- Collected spatial and temporal data, conducted data quality-control, and produced land cover, sewer network, and meteorological data in forms usable by the model.

- Verified monitoring data (runoff time series in summer 2012 and recent data since 2020) to be used for model calibration.

- Conducted automatic calibration of PCSWMM using the OSTRIC optimization software.

- Compared model simulations of runoff and TSS with observed values.

- Built PCSWMM for the project's study areas: Pickering, Ajax, Whitby, and Oshawa watersheds. Collected and verified calibration data: stormwater management network, land cover, and meteorological data. Collected TSS and phosphorus (P) data from literature and technical reports to be used in the water quality component of PCSWMM.

- Future Plans:

- Finalize the development of calibrated PCSWMM model for the two Ajax sewersheds by representing the snowmelt processes.
- Scale up the PCSWMM model for the entire study area by incorporating more detailed GIS layers of land cover and soil data.
- Combine the urban hydrology component (PCSWMM) with a simple representation of water balance in agricultural areas in the region to model the combined effects of agricultural and urban water and pollutants export to WLO.

Mountain Water Futures

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.

Current / Future:

- Advance the inclusion of beaver dams in catchment hydrologic models
- Investigation of wetland hydrology and type in cold alpine catchments.
- Identify influence of vegetation change on alpine hydrology.
- Quantify importance of shoulder season ET from sub-alpine forests, and identify dominant controls.

Surface/Groundwater Interactions

- 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.

Cryosphere

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

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.

Northern Water Futures

- Developed tools for aquatic ecosystem hydrological and contaminant monitoring in the Peace-Athabasca Delta, Alberta (Kay et al., 2021; Neary et al., 2021; Owca et al., 2021; Remmer et al., 2020; Savage et al., 2021).
- Predicted changes in hydrology and transboundary flows to the NWT (Thompson and Wright, 2020).
- Improved security of hydrologically sensitive infrastructure.
- *Characterizing hydrological vulnerability of shallow lakes*

    - Historic air photo analysis of the nature and rate of changes in areal extent of small lakes across the NWT coupled with targeted isotopic sampling in WBNP

- Develop plain language materials showing the types and drivers of lake change sediment to lakes

- Kay, M. L., Swanson, H. K., Burbank, J., Owca, T. J., Savage, C. A. M., Remmer, C. R., Neary, L. K., Wiklund, J. A., Wolfe, B. B., and Hall, R. I.: A Bayesian mixing model framework for quantifying temporal variation in source of sediment to lakes across broad hydrological gradients of floodplains, Limnology and Oceanography Methods, 19, 540-551, https://doi.org/10.1002/lom3.10443, 2021

- Neary, L. K., Remmer, C. R., Krist, J., Wolfe, B. B., and Hall, R. I.: A new lake classification scheme for the Peace-Athabasca Delta (Canada) characterizes hydrological processes that cause lake-level variation, Journal of Hydrology: Regional Studies, 38, 100948, https://doi.org/10.1016/j.ejrh.2021.100948, 2021

- Neary, L. K., Remmer, C. R., Krist, J., Wolfe, B. B., and Hall, R. I.: A new lake classification scheme for the Peace-Athabasca Delta (Canada) characterizes hydrological processes that cause lake-level variation, Journal of Hydrology: Regional Studies, 38, 100948, https://doi.org/10.1016/j.ejrh.2021.100948, 2021

- Savage, C. A. M., Owca, T., Kay, M. L., Faber, J., Wolfe, B. B., and Hall, R. I.: Application of artificial substrate samplers to assess enrichment of metals of concern by river floodwaters to lakes across the Peace-Athabasca Delta, Journal of Hydrology: Regional Studies, 38, 100954, https://doi.org/10.1016/j.ejrh.2021.100954, 2021

Assessing Soil Moisture and Streamflow Relative to Tree-ring Reconstruction

- Tree-reconstructions of the annual and warm season flow of the Assiniboine, North Saskatchewan and Athabasca Rivers

- Hydrological (MESH) modeling of these river basins

- Comparing the various model simulations and reconstructions of the hydrology of the Athabasca River basin, in terms of the spectral and statistical properties of these time series.

- Conclusions and recommendations regarding the extent to which climate models, and thus the climate forcing of hydrological models, is lacking certain modes of natural variability that are evident in longer (proxy) hydrological records

Prairie Groundwater

- Developing an integrated hydrologic model for a representative, shallow, Canadian Prairies aquifer (Dalmeny)

- Identifying potential climate and land/water use scenarios for the model

- Finalizing GAMLSS results for correlation between baseflow and climate indices

- Starting correlation analysis between streamflow and baseflow trends with GRACE/GRACE-FO data

- Identifying additional representative groundwater systems for Saskatchewan

- Improved understanding of the potential effects of increased groundwater use in the Canadian Prairies using a suite of groundwater tracers, hydrograph analyses and numerical models
    - Identify representative groundwater systems in the Canadian prairies

- Development of a geochemical catalog of environmental tracers for groundwater systems in the Canadian Prairies
- Development of integrated hydrologic model for Dalmeny basin & other representative aquifer systems
    - Model scenarios to demonstrate potential changes to surface and groundwater availability due to changes in climate, land use and water use
- Baseflow and hydrograph trend analysis to identify regions susceptible to streamflow depletion
    - Correlation to climate indices to indicate susceptibility to climate change
- Integration of geological, hydrogeology, geochemical data, numerical models and statistical analyses to develop conceptual models of representative groundwater systems in the Canadian Prairies

Saint John River Experiment

- External data covering the Saint John River basin (ERA5/ERA5 land, hydrological data, DEM data, etc.) have been extracted for analysis, modelling, and GIS use.

Transformative Sensor Technologies and Smart Watersheds

- Development and deployment of ACRO drone over research basins to investigate hydrological processes with integrated lidar, RGB, multispectral and thermal remote sensing.
- Incorporation of AI-based hydrologic triggering algorithms into the iWT data logging system (coll. Solinst Canada).
- Focused prairie snowmelt monitoring campaigns with ACRO drones to quantify the spatial variability of Canadian prairie depression focused hydrology (evaluating abilities to quantify snowmelt, runoff, depression storage and infiltration dynamics).
- Improved accuracy characterization of soil processes and plant transpiration for precision agriculture applications and quantification of hydrological processes.