Global Water Futures (GWF) Planetary Water Prediction Initiative (PWPI)

Summary and Overview
December 1, 2021

PWPI webpage: https://gwf.usask.ca/core-modelling/modelling-domain/planetary-water-prediction-initiative.php
GWF international links and partnerships: https://gwf.usask.ca/projects-facilities/global-programs.php

Overview and Vision

Global Water Futures (GWF) and its institutional partners are committed to international leadership in water science for cold regions. We are developing new transdisciplinary science, new environmental monitoring systems and predictive modelling tools, and novel user-focused approaches to putting new knowledge into action, providing urgently needed risk management technologies, decision-making tools, and other evidence-based solutions to complex water challenges.

In response to the call for action issued by the World Meteorological Organization High Mountain Summit, and UNESCO's IHP-IX strategic plan "Science for a Water Secure World in a Changing Environment", GWF has launched the Planetary Water Prediction Initiative (PWPI) as an extension of our core modelling and forecasting team efforts. **The PWPI advances the computational infrastructure (datasets, modeling capabilities) necessary to produce global-domain simulations and predictions of hydrological risks. Moreover, PWPI will use these state-of-the-art modeling capabilities to develop new and strategic collaborations with organizations and countries, through mutually beneficial, internationally focussed projects.** PWPI will involve collaboration with countries in the Americas, Asia, Africa, 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 local and downstream water demands and ecosystem needs. Major areas of international collaboration and support with GWF will primarily focus on high mountain and cold regions, which are the recognized strengths of GWF.

Models

GWF's PWPI is built around several modelling platforms that have been developed and refined by GWF and its predecessor research networks, assembling process-level understand and model parameterizations from cold regions around the world from many decades of field research.

Modélisation Environmentale Surface and Hydrology (MESH) model

MESH is a stand-alone land-surface–hydrology scheme designed with Environment and Climate Change Canada for both forecasting and open loop (i.e., without feedbacks to the atmosphere) simulations. As a hydrology modelling system, MESH captures many of the important land-surface processes necessary for cold-regions simulation. It is a flexible modelling framework that facilitates inter-comparison of alternative algorithms and models (e.g., land surface schemes and routing schemes), and can be applied over vast river basins. **MESH Wiki**

Cold Regions Hydrological Modelling (CRHM) platform

CRHM is a flexible modelling system originally developed in Environment Canada that can be used to generate a process hydrology model, specific to the needs of the user. A functioning model is built by selecting various process modules from a library based on several decades of hydrological research. CRHM can be applied at point scales and over small to medium sized river basins to simulate system behavior and response to climate and other changes and is particularly useful for disentangling complex process interactions between climate, vegetation, snow, glaciers, permafrost, land management, surface–atmosphere fluxes, and runoff. **CRHM description and download**

Canadian Hydrological Model (CHM)

CHM is a multi-scale and multi-resolution hydrological model. It uses a variable resolution mesh to capture fine-scale variability where it exists, while reducing computational demands by reducing resolution in other parts of the domain. It has the design goals of i) multi-scale, multi-physics, variable complexity and domain, ii) assessment of model structural,

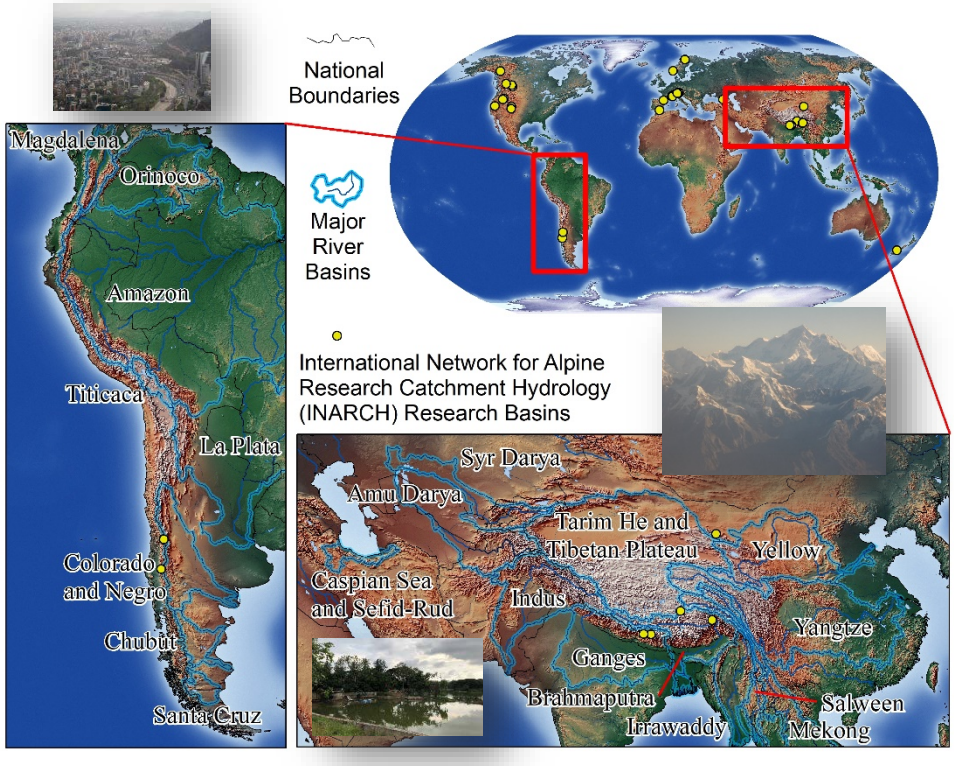
parameter, and data uncertainty, iii) ability to test multiple hypotheses, avoid rigid model structures, iv) incorporating existing code, and v) contributing to decision support systems. Many existing process algorithms from **CRHM** and the modular, physics-based continental-capable **SUMMA model** have been ported into CHM, and given its flexibility and robustness, CHM represents the next generation in cold regions hydrological prediction with the capability to bridge scales for prediction and forecasts from local to large areas. **https://github.com/Chrismarsh/CHM**

GWF is also utilizing other models, developed and/or applied within our core modelling efforts (https://gwf.usask.ca/core-modelling/), to support PWPI. Of note is our strong collaboration with the US National Center for Atmospheric Research, which is providing high-resolution, convection-permitting state-of-the-art Weather Research and Forecasting (WRF) atmospheric forecasting and land-surface model driving data for continental domains, driven by RCMS nested within GCMs under future atmospheric conditions.

Geographic Focus and Targets

PWPI is comprised of both global-domain projects to be implemented using available global data products and covering all regions across the world, and regionally nested and more focused applications in select areas where collaborations exist or are developed, and where targeted goals and questions will be addressed. First, we are building the computational infrastructure (models, data) to enable state-of-the-art hydrological simulations anywhere on the planet. This involves assembling and improving global datasets on climate forcing, digital elevation models, vegetation, soils, etc., and using these datasets to configure hydrological models for the global domain. Second, we are developing regional models in key regions where we have strong collaborations (Himalaya, Andes, central Asia) to address pressing societal needs. The regional models are constructed as cut-outs from the global-scale fabric, and the global instantiations are used as a baseline to systematically evaluate the benefits of specific regional information (e.g., regional DEMs). The activities include regional forecasting, diagnostic and predictive modelling of hydrological systems, and climate sensitivity analyses for the purpose of informing local management, decision making, and policy development, and strengthening local resilience to anticipated changes.

PWPI is now well underway with ongoing projects and collaborations in many focal regions. We are working with regional partners on specific activities, including the application of CHM in the Pyrenees Mountains of Spain, CRHM in Andes (Chile) and Himalayas (Nepal), MESH in Central Asia, India, Iran, and the Andes, and CHM extension from the Bow River Basin in Canada to larger domains over the Canadian Rocky Mountains and soon, North America. In due course we aim for CHM extension to the world for global water assessment and water resources mapping.



Geographic focus for the GWF PWPI.

Key regions we are focused on are the Andes of South America and the Asian highlands of the Hindu-Kush-Himalaya and Tibetan Plateau, and Central Asia. Regional activities leverage International Network for Alpine Research Catchment Hydrology (INARCH; https://inarch.usask.ca) activities and field research sites as model testbeds and hydro-meteorological observatories. Efforts will be expanded to the Arctic drainage basin, and other potential high mountain regions may include East Africa and the Atlas Mountains.