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UNIVERSITY OF CALGARY

CIROH Cooperative Institute for Research to Operations in Hydrology

NOAA

Promoting Open and Transparent Hydrologic Modeling

Wouter Knoben[1], Martyn Clark[1], Louise Arnal[2], Ashley van Beusekom[2], Dave Casson[1], Shervan Gharari[3], Kyle Klenk[2], Hongli Liu[4], Kasra Keshavarz[1], Alain Pietroniro[1], Kevin Shook[3], Ray Spiteri[3], Sean Trim[2], Tricia Stadnyk[1], Andy Wood[5,6], and others

[1] University of Calgary, [2] Ouranos, [3] University of Saskatchewan, [4] University of Alberta, [5] NCAR, [6] Colorado School of Mines

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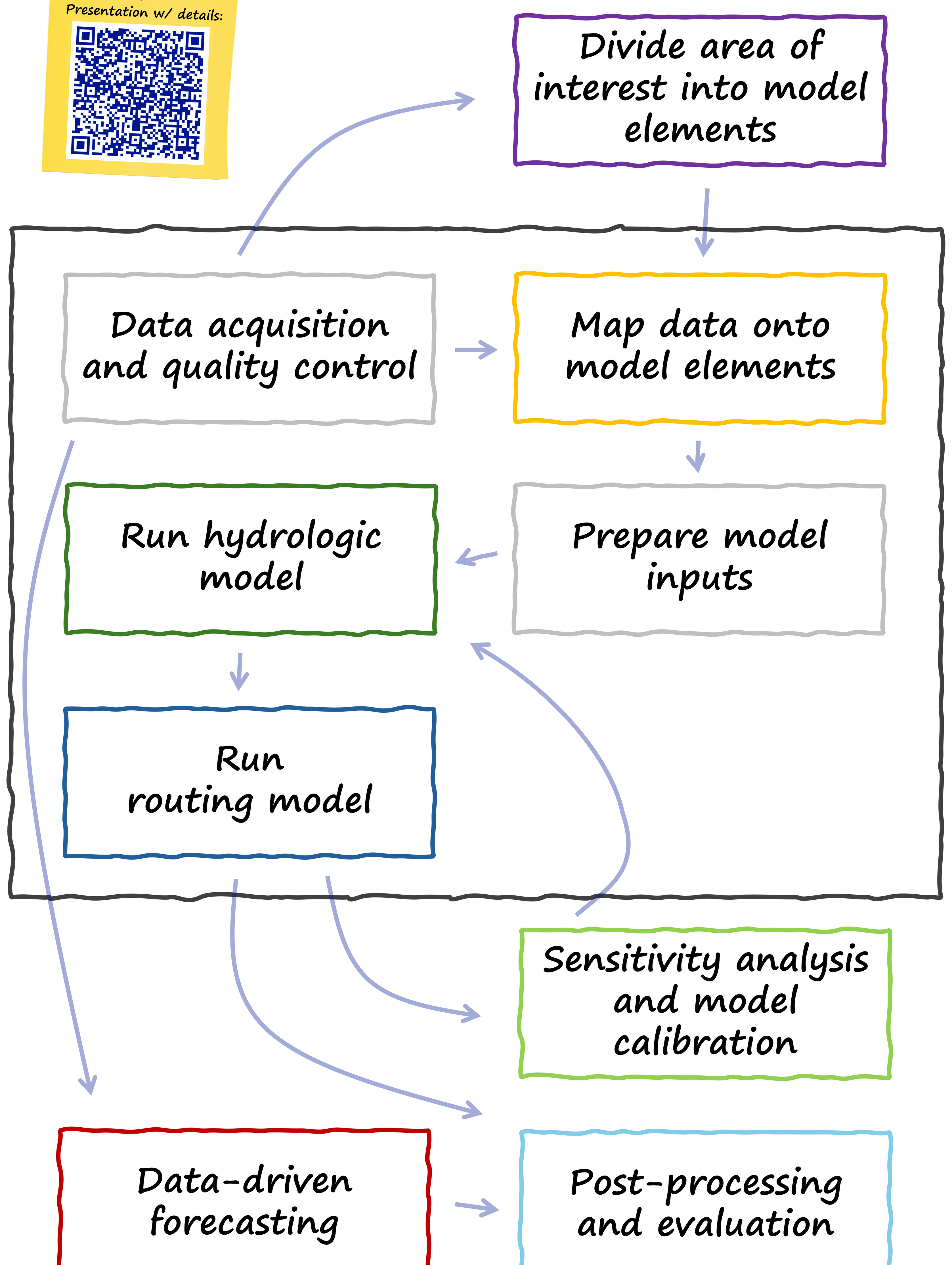
Many open-source workflows, tools and self-contained modules exist. These can promote efficiency, transparency and collaboration along all steps in the hydrologic modelling chain. Example modelling workflow below, tools on the sides.

Presentation w/ details:

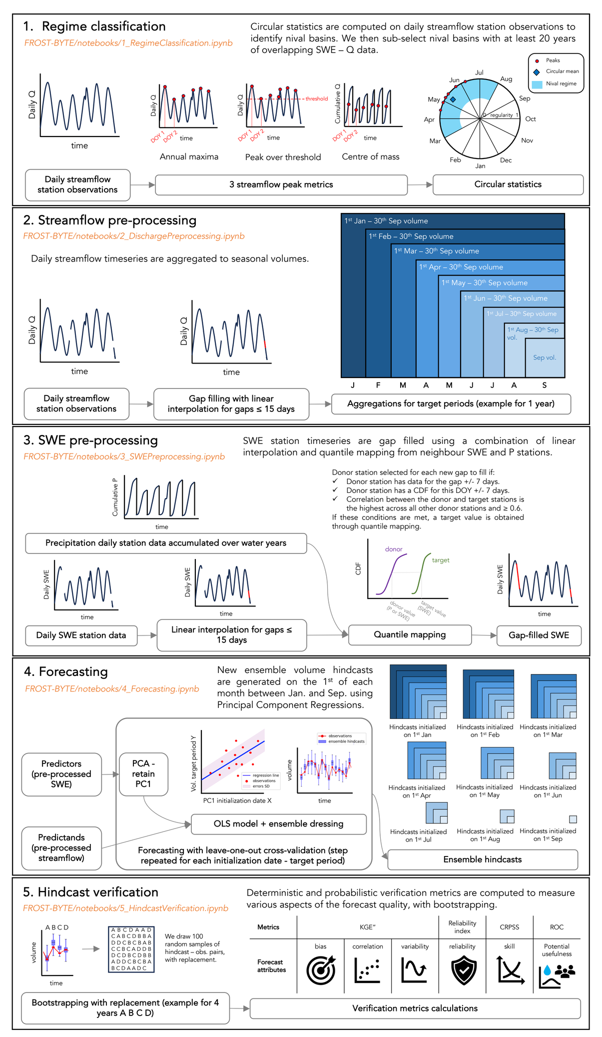


Data-driven forecasting

FROSTBYTE: A reproducible data-driven workflow for probabilistic seasonal streamflow forecasting in snow-fed river basins across North America

Louise Arnal, Martyn P. Clark, Alain Pietroniro, Vincent Vionnet, David R. Casson, Paul H. Whitfield, Vincent Fortin, Andrew W. Wood, Wouter J. M. Knoben, Brandi W. Newton, and Colleen Walford

Access: https://github.com/CH-Earth/FROSTBYTE/



Environment and Climate Change Canada / Environnement et Changement climatique Canada

Workflows

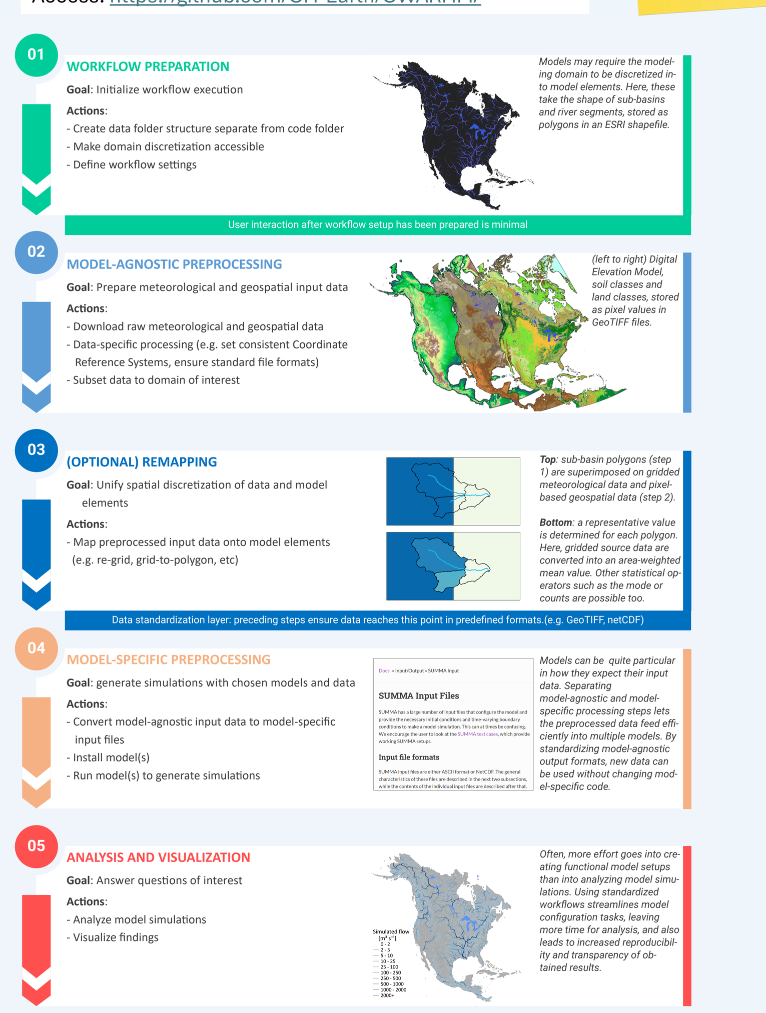
Water Resources Research

Community Workflows to Advance Reproducibility in Hydrologic Modeling: Separating Model-Agnostic and Model-Specific Configuration Steps in Applications of Large-Domain Hydrologic Models

W. J. M. Knoben, M. P. Clark, J. Bales, A. Bennett, S. Gharari, C. B. Marsh, B. Nijssen, A. Pietroniro, R. J. Spiteri, G. Tang, D. G. Tarboton, A. W. Wood

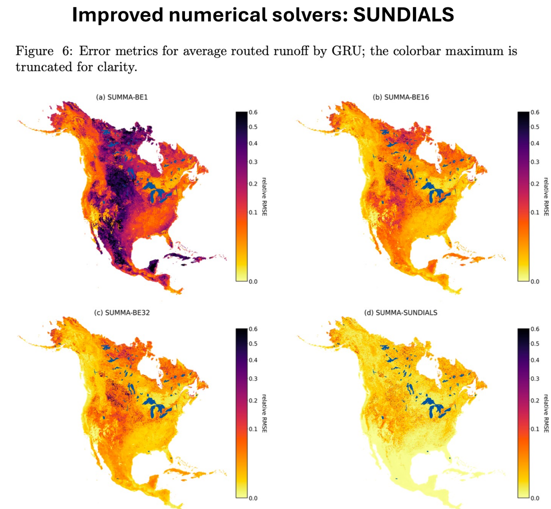
Access: https://github.com/CH-Earth/CWARHM/

Enhancements:
- Snakemake workflow management (Dave)
- Model Agnostic Framework (Alain, Kasra)

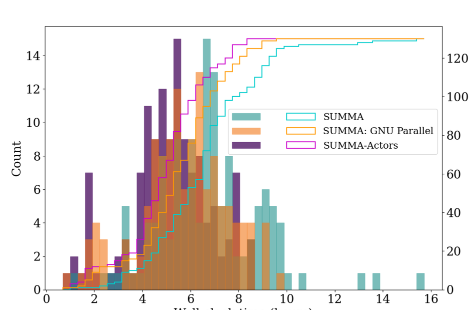


Numerical implementation

Improved numerical solvers: SUNDIALS

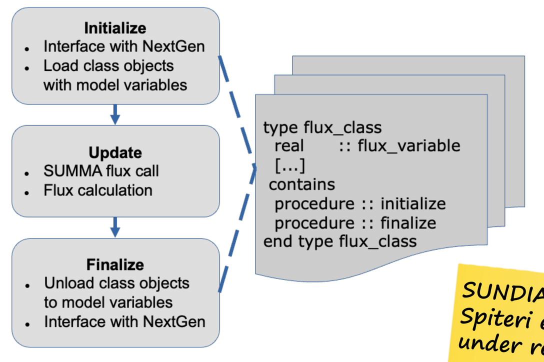


Improved parallelization: The Actors model



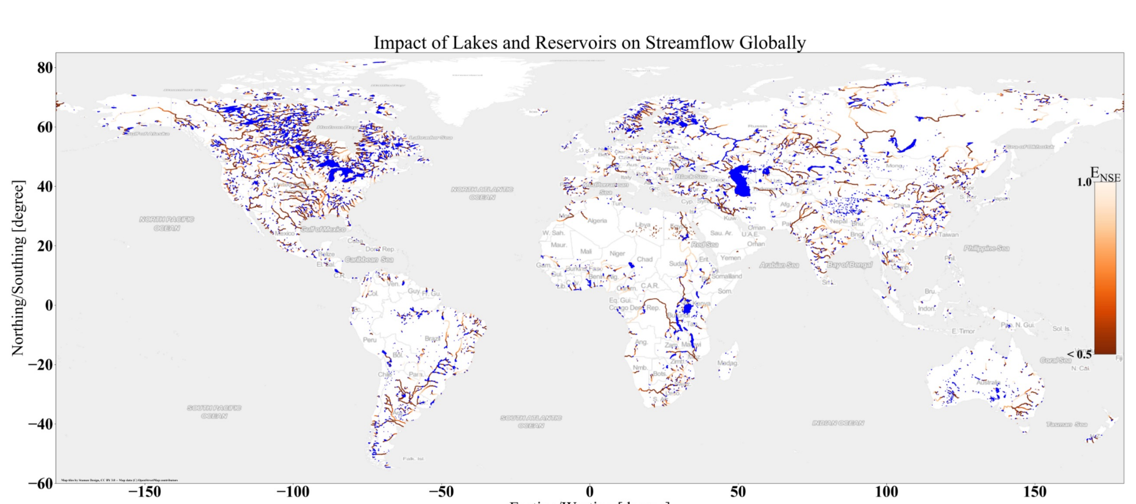
Access:
- https://github.com/LLNL/sundials
- https://git.cs.usask.ca/kck540/SummaActors
- https://github.com/seantrim/summa/tree/develop_refactor_Newton

Improving modularity and interoperability: Code refactoring
- Object-oriented approaches in Fortran
- Initialize/finalize steps allow generalized interfacing
- Works with any data structures desired
- Concise and modular code



SUNDIALS: Spiteri et al. (JAMES, under review)
Actors: Klenk & Spiteri (Cluster Computing)
Refactor: Trim et al (in prep)

Lakes and reservoirs



Evaluating a reservoir parametrization in the vector-based global routing model mizuRoute (v2.0.1) for Earth system model coupling

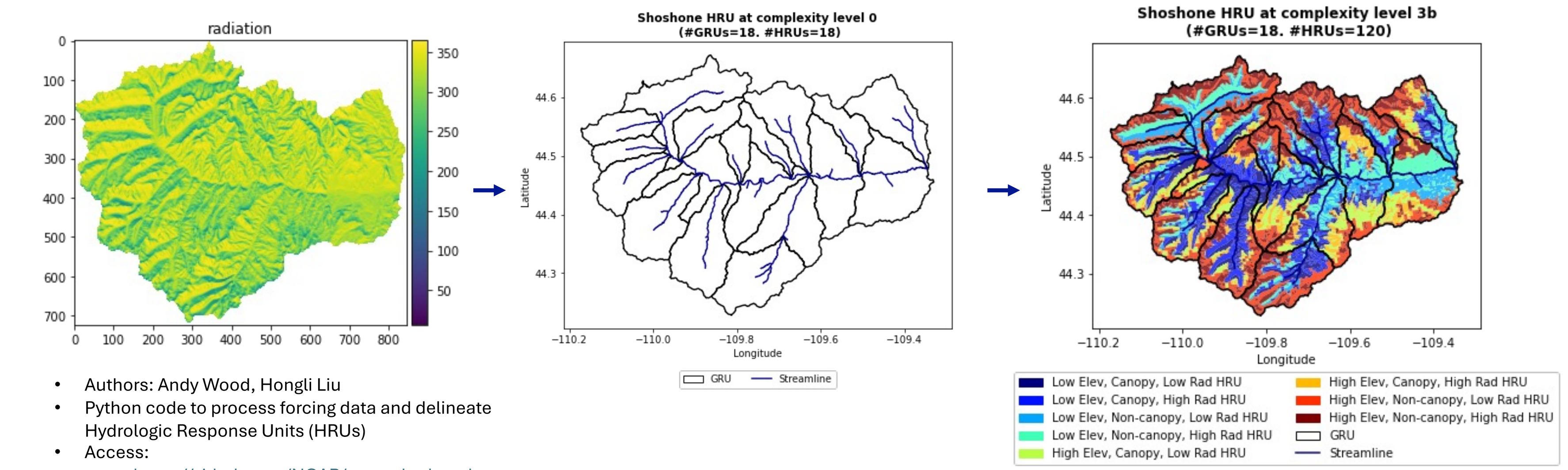
Inne Vanderkelen, Shervan Gharari, Naoki Mizukami, Martyn P. Clark, David M. Lawrence, Sean Swenson, Yadu Pokhrel, Naota Hanasaki, Ann van Griensven, and Wim Thiery

A Flexible Multi-Scale Framework to Simulate Lakes and Reservoirs in Earth System Models

S. Gharari, Inne Vanderkelen, Andrew Tefs, Naoki Mizukami, Erik Kluzek, Tricia A. Stadnyk, David Lawrence, Martyn P. Clark

Access: https://github.com/ESCOMP/mizuRoute/

Spatial discretization



- Authors: Andy Wood, Hongli Liu
- Python code to process forcing data and delineate Hydrologic Response Units (HRUs)
- Access:
  - https://github.com/NCAR/watershed_tools

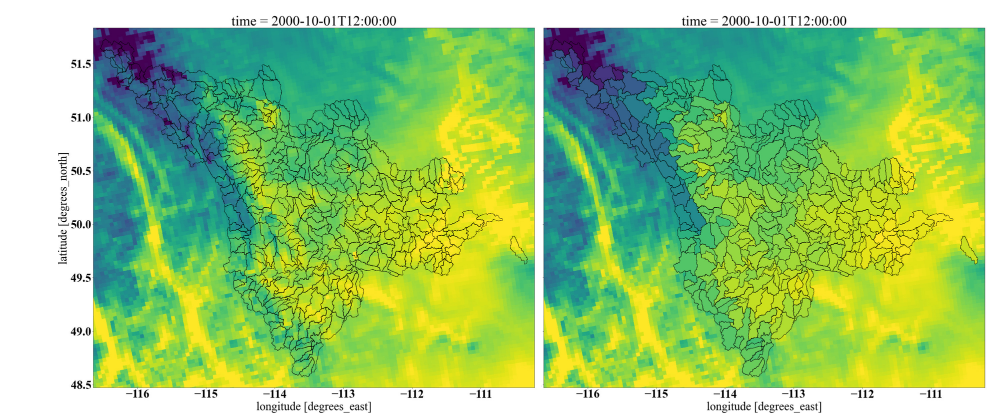
Data remapping

SoftwareX

EASYMORE: A Python package to streamline the remapping of variables for Earth System models

Shervan Gharari, Kasra Keshavarz, Wouter J.M. Knoben, Guoqiang Tang, Martyn P. Clark

- Python package to map data from one spatial configuration to another
- Multiple workflow examples available
- Access:
  - https://github.com/ShervanGharari/EASYMORE
  - pip install easymore



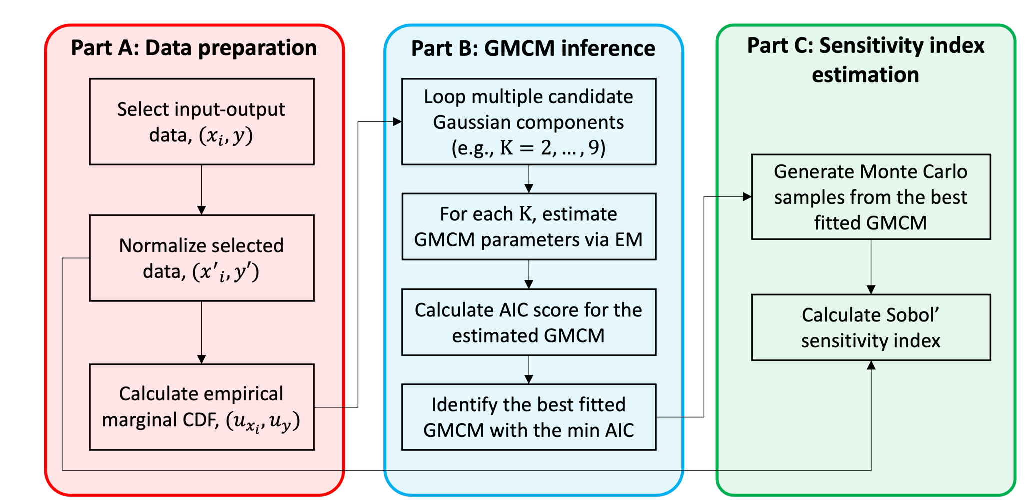
Sensitivity analysis

Water Resources Research

An Improved Copula-Based Framework for Efficient Global Sensitivity Analysis

Hongli Liu, Martyn P. Clark, Shervan Gharari, Razi Sheikholeslami, Jim Freer, Wouter J. M. Knoben, Christopher B. Marsh, Simon Michael Papalexiou

- Python package to estimate Sobol' sensitivity indices from existing simulations
- Computationally frugal
- Access:
  - https://github.com/CH-Earth/pyviscous
  - pip install pyviscous



Previously neglected processes

Water Resources Research

The Numerical Formulation of Simple Hysteretic Models to Simulate the Large-Scale Hydrological Impacts of Prairie Depressions

Martyn P. Clark, Kevin R. Shook

Environmental Modelling & Software

Implementing a parsimonious variable contributing area algorithm for the prairie pothole region in the HYPE modelling framework

Mohamed Ismaiel Ahmed, Kevin Shook, Alain Pietroniro, Tricia Stadnyk, John W. Pomeroy, Charlotte Pers, David Gustafsson