EVALUATE UNCERTAINTY FROM SNOW PROCESSES OF A PHYSICS-BASED INTEGRATED HYDROLOGIC MODEL USING GLUE AND GAUSSIAN PROCESS EMULATOR

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1. Objectives

- Explore the **uncertainty** from snow processes of a physics-based integrated hydrologic model.
- Parameter **calibration** of integrated modeling system with multivariate output.

2. Introduction

- Quantification of uncertainty of environmental models plays an important role in the decision making process.
- Parameter uncertainty is one of the major sources of uncertainty, which comes from the model parameters that are inputs to the computer model but whose exact values are unknown to experimentalists and cannot be controlled in physical experiments.
- Monte Carlo methods based on a large number of random sampling have been widely used in the parameter uncertainty analysis. Due to the increasing complexity and computational cost of such environmental models, Monte Carlo sampling is unrealistic for propagating parameter uncertainty.
- The Bayesian approach using Gaussian process (GP) emulator has attracted much attention in the uncertainty analysis of computationally expensive models.

It would be useful to evaluate the capability and uncertainty of each processes simulation within the framework of a physics-based integrated hydrologic model. This study uses Penn State Integrated Hydrological Model (PIHM) as an example to evaluate parameter uncertainty from snow processes.

3. Study Area and Model Setup

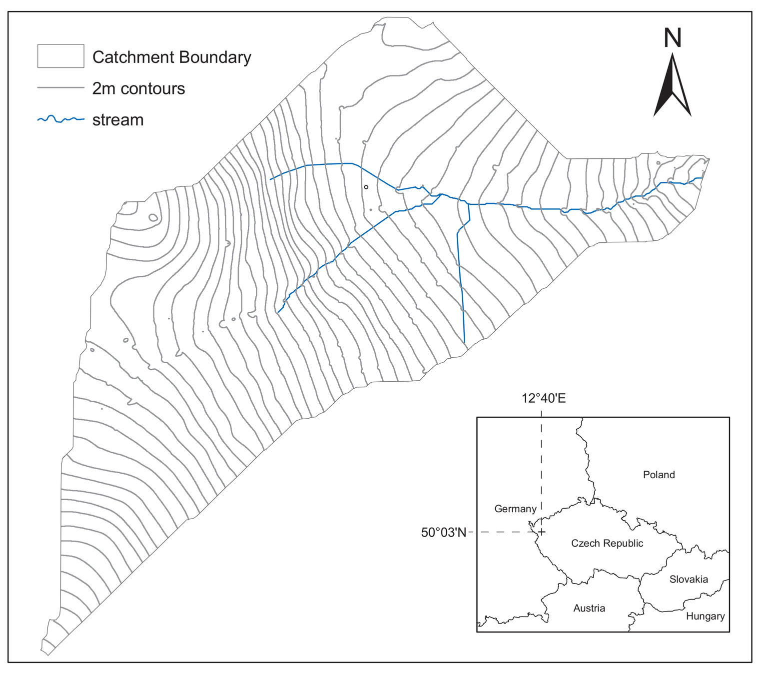

Figure 1: *Location of Lysina.*

The study site Lysina headwater catchment is located 50° 03' N, 12°40' E in the western part of the Czech Republic (Figure 1), where 40% of its precipitation is in the form of snow.

To evaluate uncertainty of snow processes, we use a physics-based integrated hydrologic model: PIHM to simulate the winter hydrologic processes. PIHM integrates the hydrological processes including snow accumulation and melt, interception, throughfall, infiltration, recharge, evapotranspiration, overland flow, groundwater flow, and channel routing, in a fully coupled scheme (Figure 2).

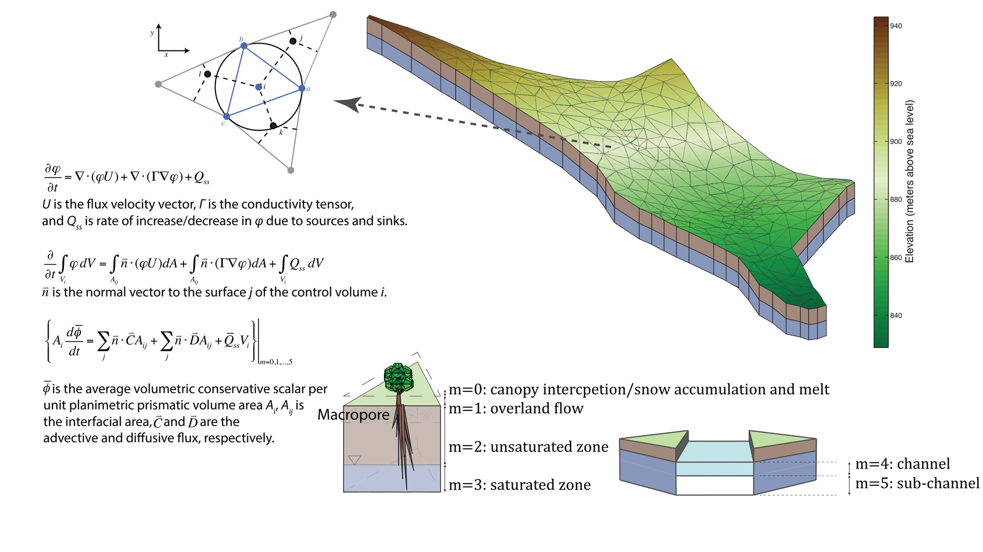

Figure 2: *The PIHM representation of hydrological processes and coupling strategy.*

4. Generalized Likelihood Uncertainty Estimation (GLUE)

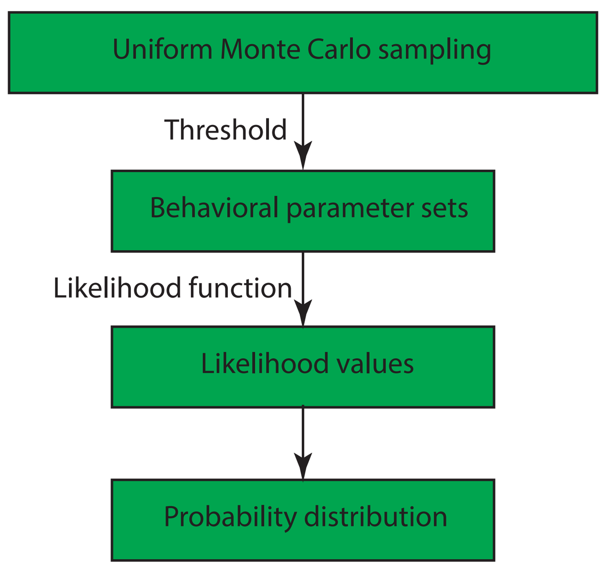

Figure 3: *The GLUE procedure.*

The users need subjectively select the likelihood functions and the threshold.

5. Gaussian Process Emulator

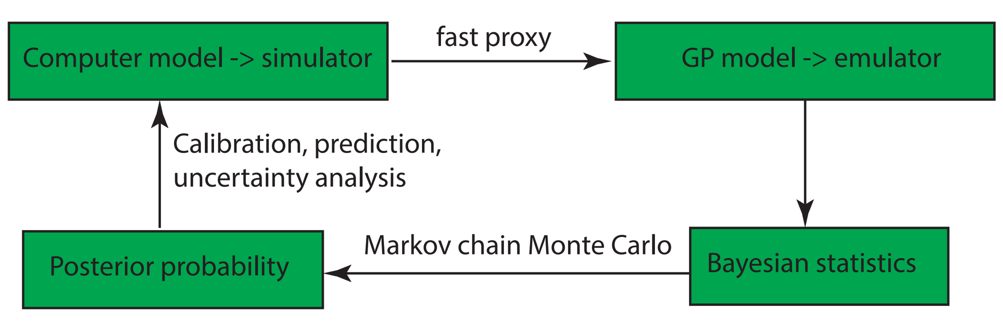

Figure 4: *The GP emulation procedure.*

6. Results

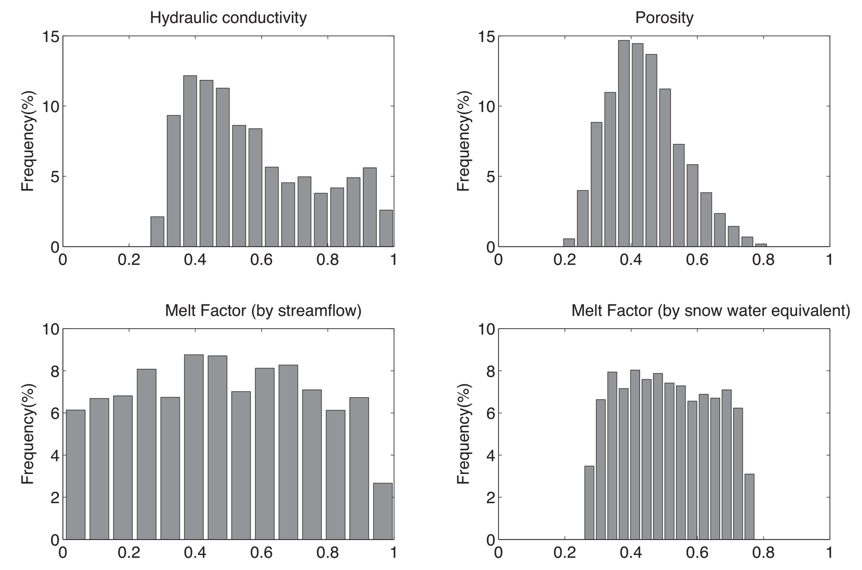

Figure 5: *Posterior distribution of GLUE with threshold of NSE>0.8.*

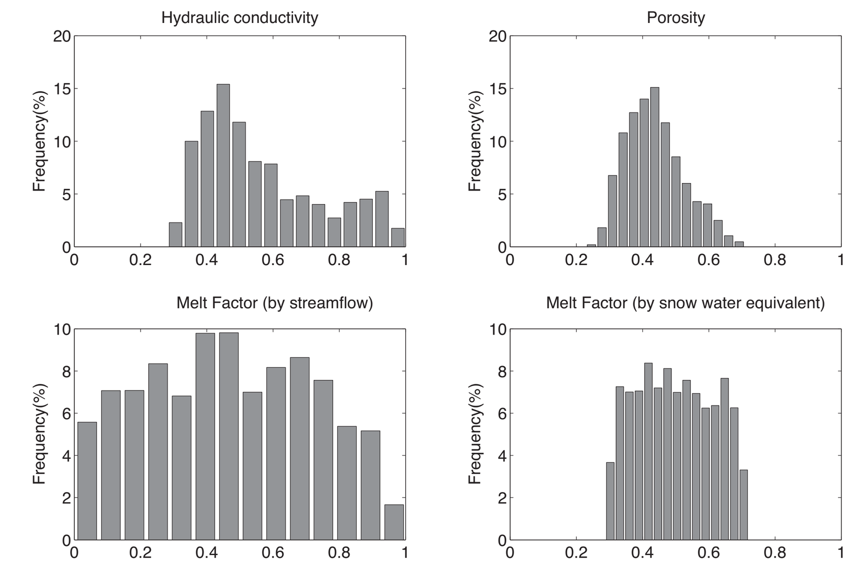

Figure 6: *Posterior distribution of GLUE with threshold of NSE>0.85.*

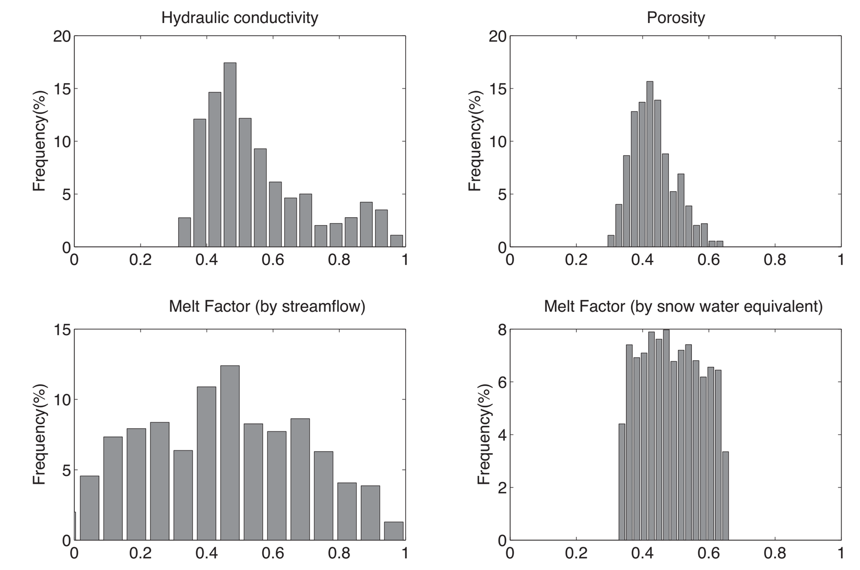

Figure 7: *Posterior distribution of GLUE with threshold of NSE>0.9.*

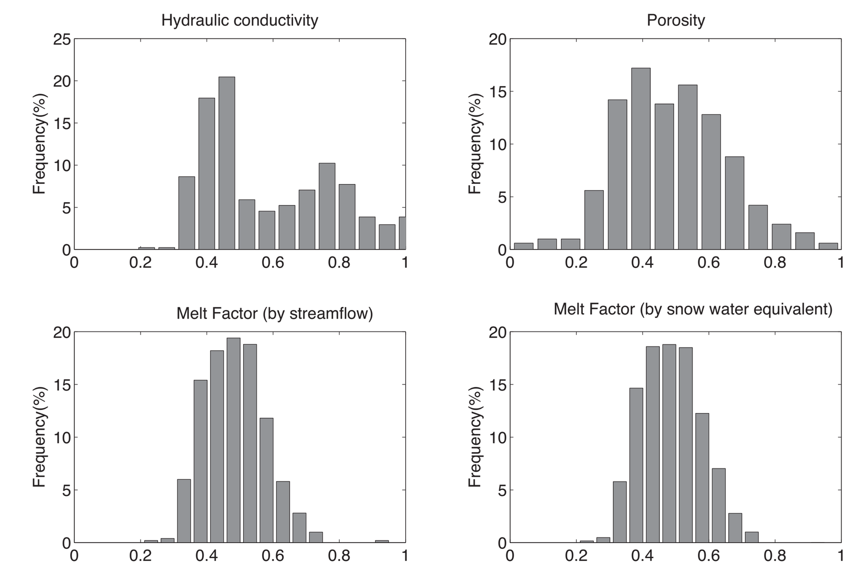

Figure 8: *Posterior distribution of GP emulator.*

7. Implications

- The uncertainty of hydraulic conductivity showed multimodal distributions, even with long MCMC chains.
- The posterior distribution of melt factor suggested that it is sharper and narrower constrained by streamflow than that of constrained by snow water equivalent.

8. Acknowledgement

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