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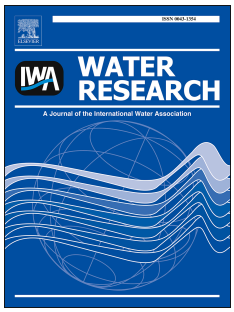

A dynamic emulator for physically based flow simulators under varying rainfall and parametric conditions

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Physically based model ⟶ Surrogate model

Rainfall, I(t)

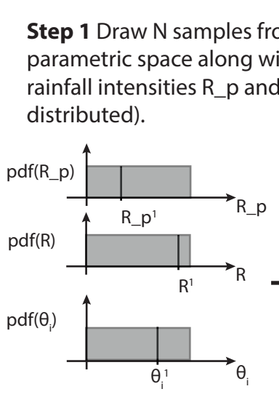
M(θ, I(t)) → Outflow Q(θ, t)

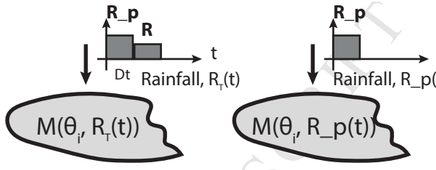
Infiltration/losses

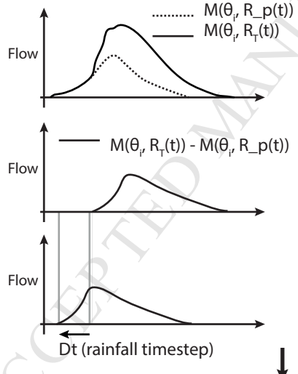
e.g. 2D-SWE solution

Simplification phase 1, Polynomial chaos expansion (PCE) unit hydrograph emulation.

Step 1 Draw N samples from the model parametric space along with unitary rainfall intensities R_p and R (uniformly distributed).







Step 2.1 Sample the model and compute the difference between the flow response under $R_T(t)$ and R_p(t).

Step 2.2 Shift the resultant hydrograph one rainfall timestep (-Dt). And create a database of N shifted model samples (at combinations of [θ, R_p, R])

Perform more samples from the simulator if the interpolation is not satisfactory

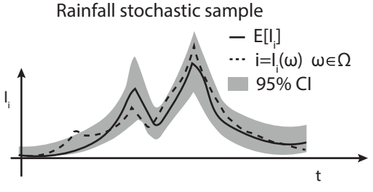
Step 3, Mapping parameters to the unitary flow response (training of PCE)

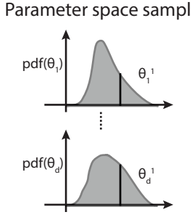
UH_p_s(θ, R_p, R)

Step 4 Check the performance of the PCE emulator using a test database.

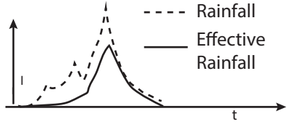
Simplification phase 2, Rainfall to flow by superposition of unitary responses

Step 5 Sample from the rainfall and parameter spaces



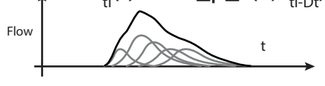


Step 6 Compute effective rainfall (Infiltration/losses model)



Step 7 Interpolate (using the PCE) unit responses at each effective rainfall step I_{ti} accounting for the previous rainfall intensity I_{ti-1}. Compose the full hydrograph by superposition

$UR_{ti}(t) = UH\_p\_s(\theta, I_{ti-Dt}, I_{ti})$



Step 8 Compare the physically based model and emulator flow output

Practical use of the emulator:

M(θ, I(t)) → Q(θ, t)

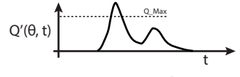
≈

UH_p_s(θ, R_p, R) → Q'(θ, t)

Fast Sampling

e.g.

- Early warning flooding schemes:



- Uncertainty quantification