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Flood prediction in a compound channel using machine learning techniques

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QUICS

EmuMore

Flood prediction

- Water surface elevation at inundated areas in respect to time
- Flood warning schemes
- Fast and accurate results
- Models
  - uncertainty
- Observed data
  - lack of data

Flood models

- Phenomenological models
- Empirical models
- Conceptual models
- Low-fidelity models

fast but not accurate results

- Physically-based models
- Detailed models
- Fine models
- High-fidelity models

accurate but no fast results

Flood models

- Phenomenological models
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fast but not accurate results

emulators

trained with data derived by detailed simulators

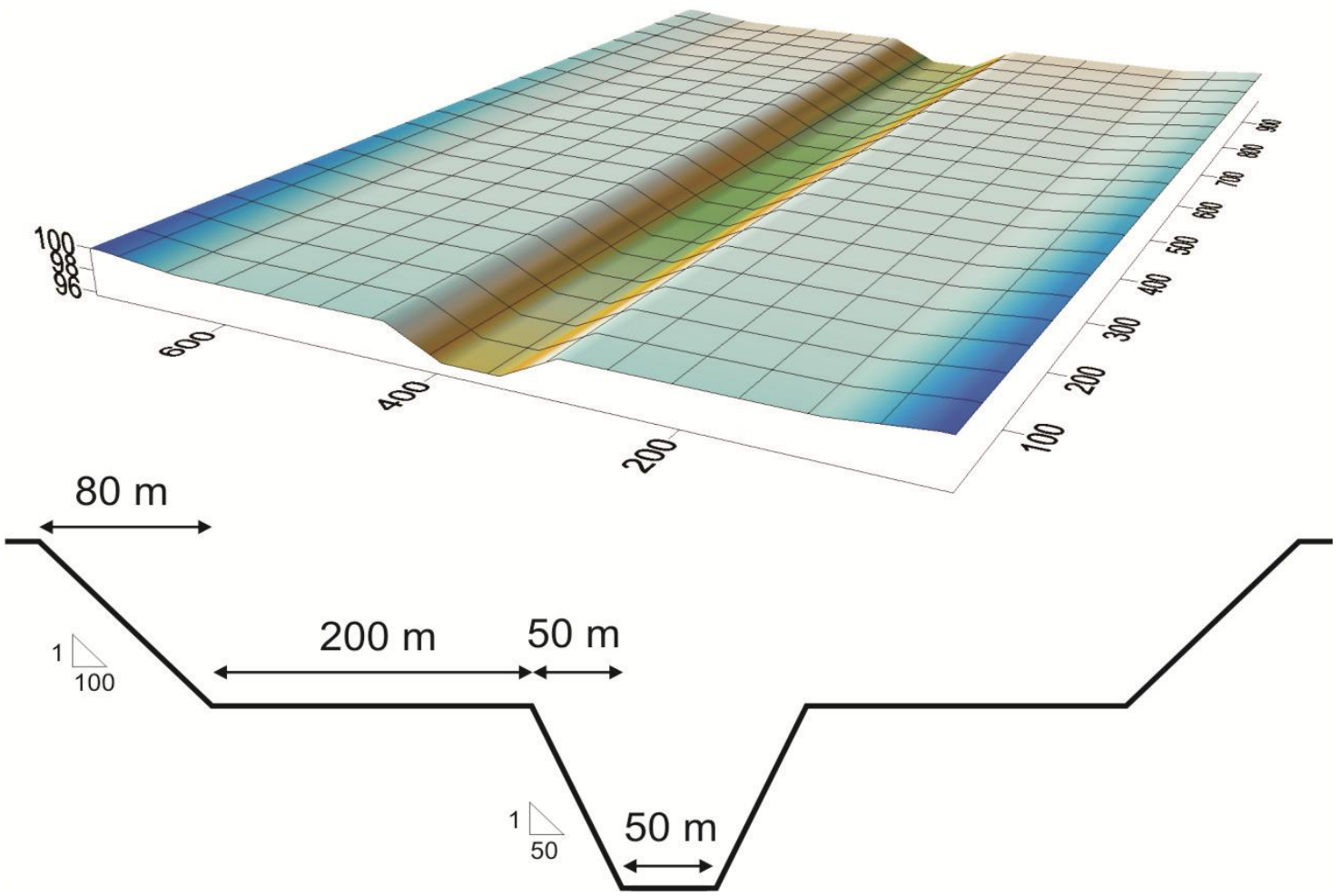
- Physically-based models
- Detailed models
- Fine models
- High-fidelity models

accurate but no fast results

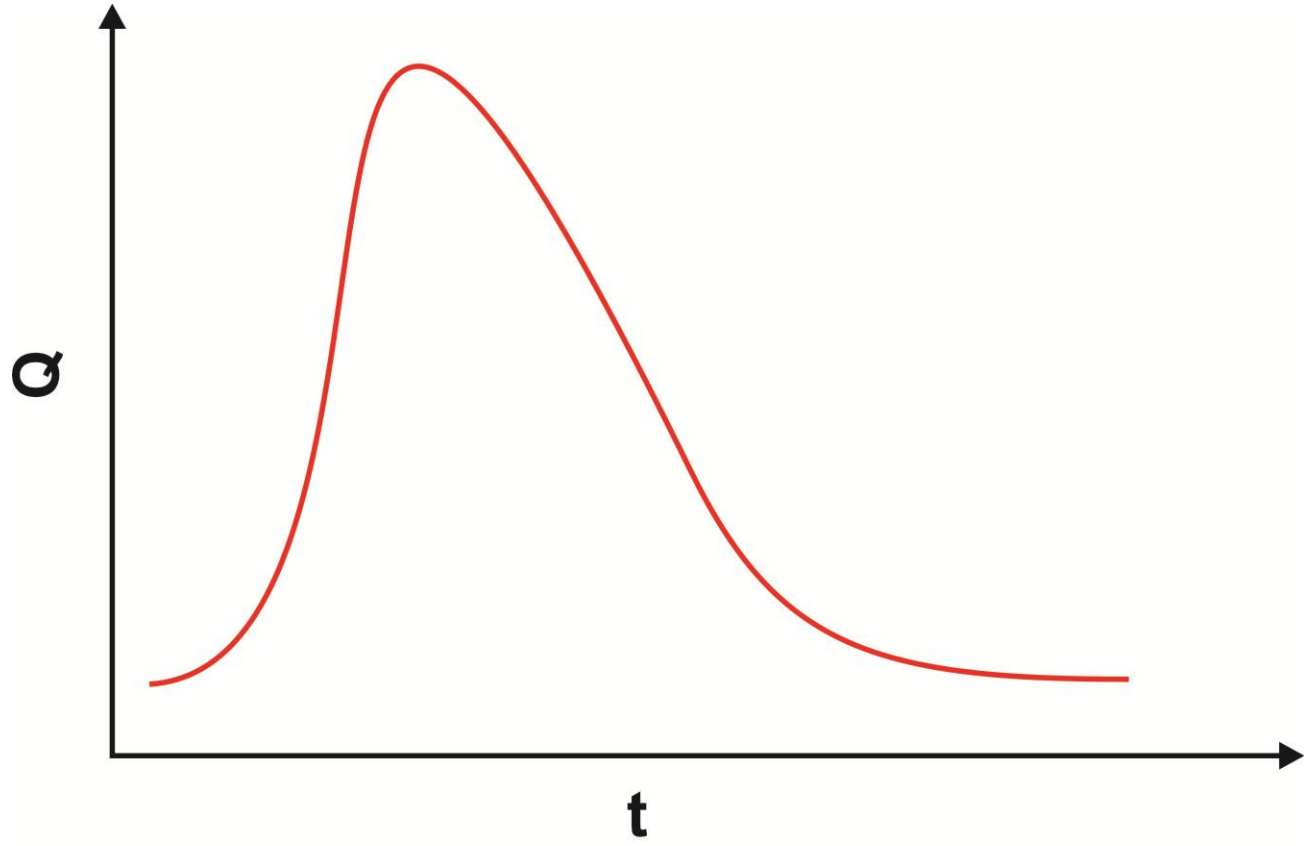
Example

- Topography → compound channel
- Input → synthetic flood hydrograph
- Output → water surface elevation in respect to time
- Simulator → FLOW-R2D model
- Emulator → Gaussian Process based

Topography

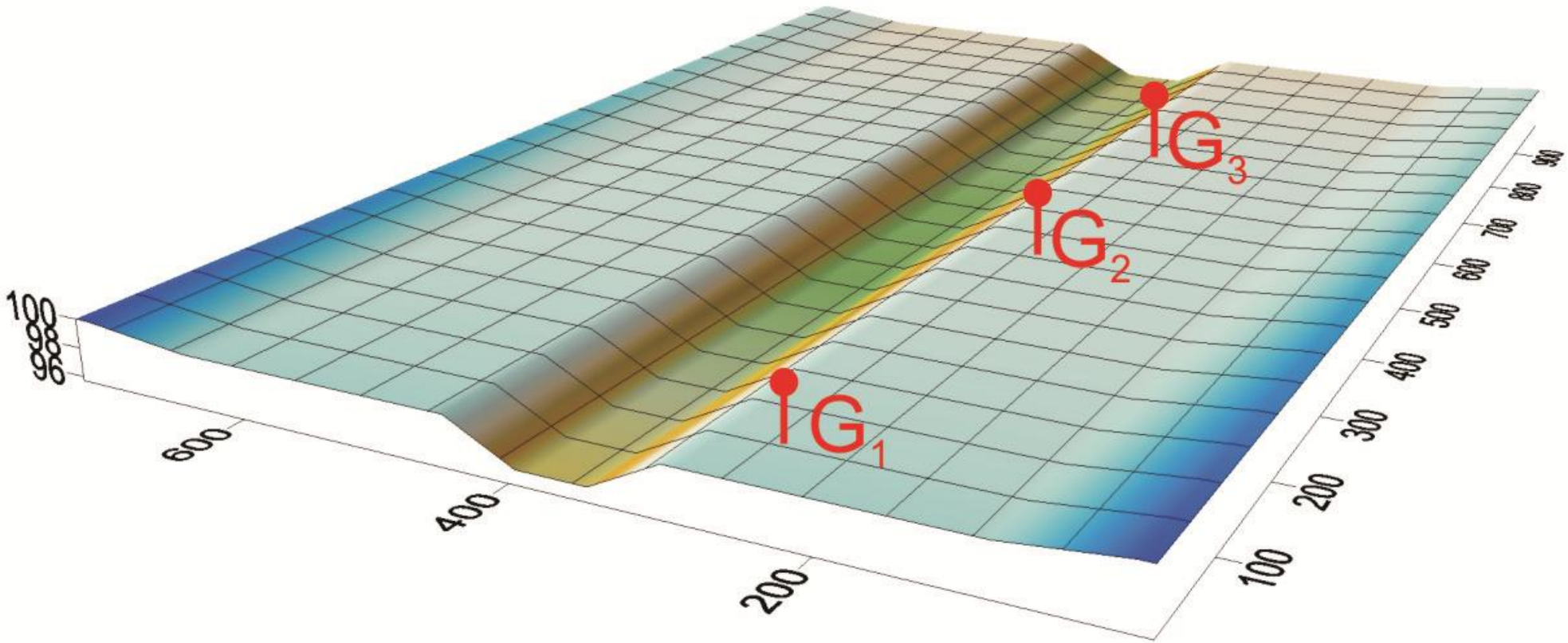

600
400
200
100
200
300
400
500
600
700
800
900
80 m
1
100
200 m
50 m
1
50
50 m

Input



$$Q(t) = Q_0 + (Q_p - Q_0)\left[\frac{t}{t_p} exp\left(1 - \frac{t}{t_p}\right)\right]^{\beta}$$

Output



Simulator

- FLOW-R2D model
- Solving the 2D-SWE using FDM
- Modified McCormack numerical scheme
- Artificial viscosity is added
- Water depth threshold for wet/dry modelling
- Manning equation
  - friction modelling
  - effective slope for upstream boundaries

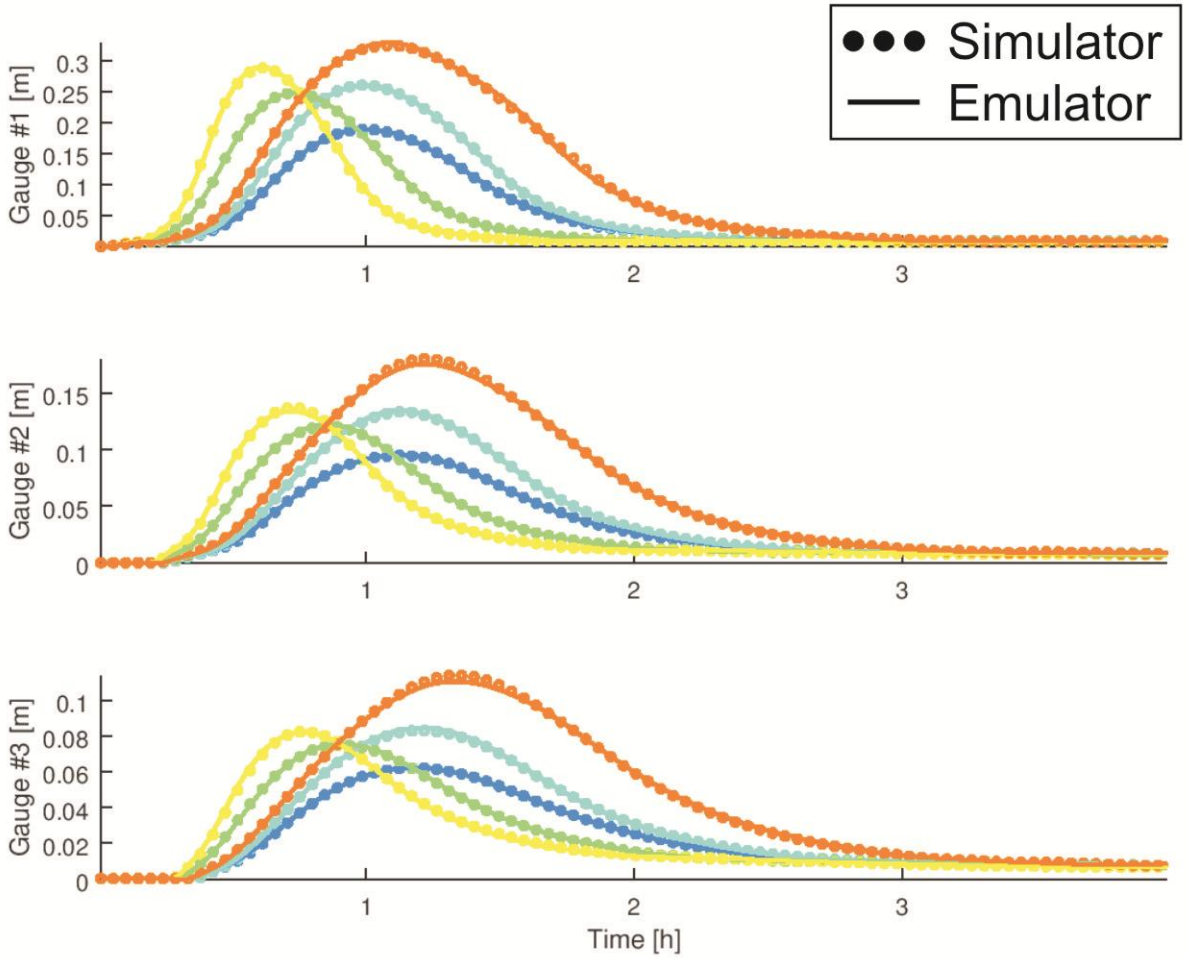
Emulator

- 3 water depth time series
  - time-parameterized 3D curve
- Decomposition
  - time dependant singular vectors
- Gaussian Process
  - linear mean function
  - square exponential covariance functions
  - optimization of hyperparameters

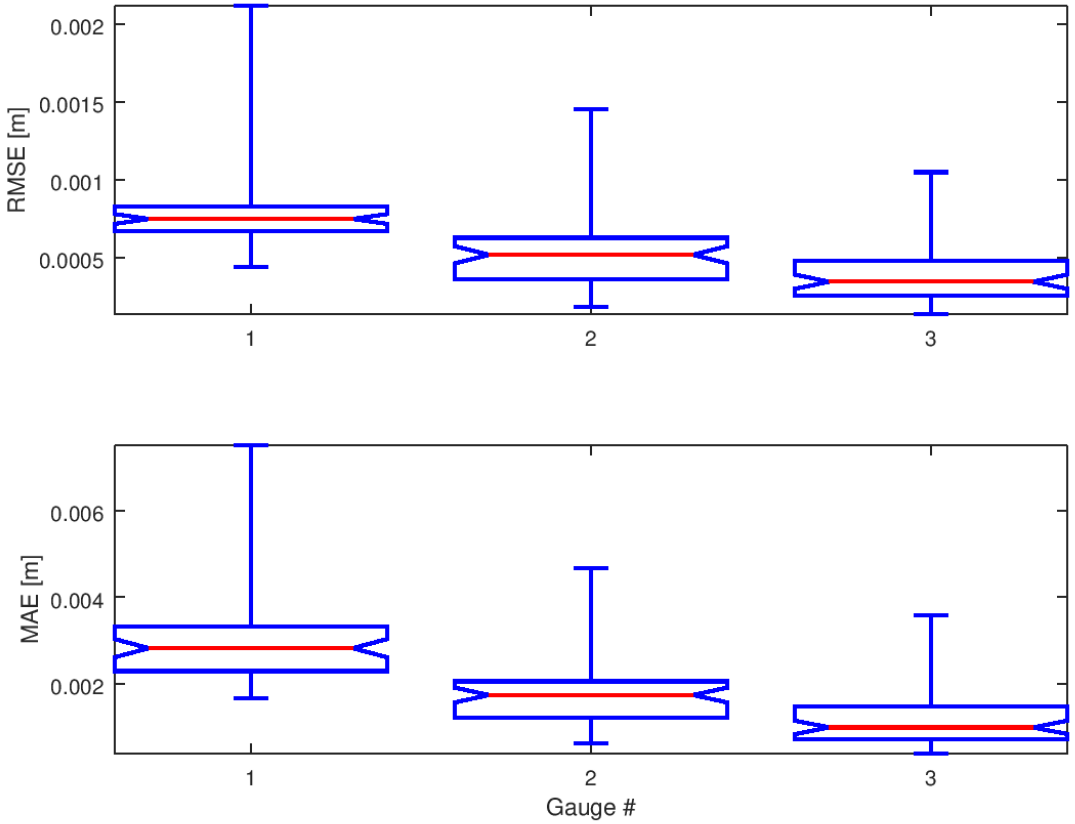
Training phase

- Training dataset → 140 samples
- Testing dataset → 60 samples
- Parametric space → Q_p[400,600] m^3/s
  t_p[0.5,1.0] h
  β[2.5,3.5]

Comparison


Simulator
Emulator
Gauge #1 [m]
0.3
0.25
0.2
0.15
0.1
0.05
1
2
3
Gauge #2 [m]
0.15
0.1
0.05
0
1
2
3
Gauge #3 [m]
0.1
0.08
0.06
0.04
0.02
0
1
2
3
Time [h]

Emulator error



Conclusions

- Significant acceleration of the simulations
  - magnitude of hours → magnitude of seconds
- Small emulator error
- Feasible to use detailed simulators
  - flood warning schemes
  - uncertainty quantification
  - designing
  - ...
- Challenges
  - computational budget
  - time-varying input and output

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