EmuMore

Boosting flood warning schemes with fast emulator of detailed hydrodynamic models

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Flood warning schemes

- Predicting time response for several water levels at critical points
- Combining models
  - rainfall-runoff
  - dam-breach
  - wind wave
  - hydrodynamic
- Fast and accurate results
- Computational burden
  - 2D hydrodynamic simulators
- Emulators
  - training data derived by detailed simulators

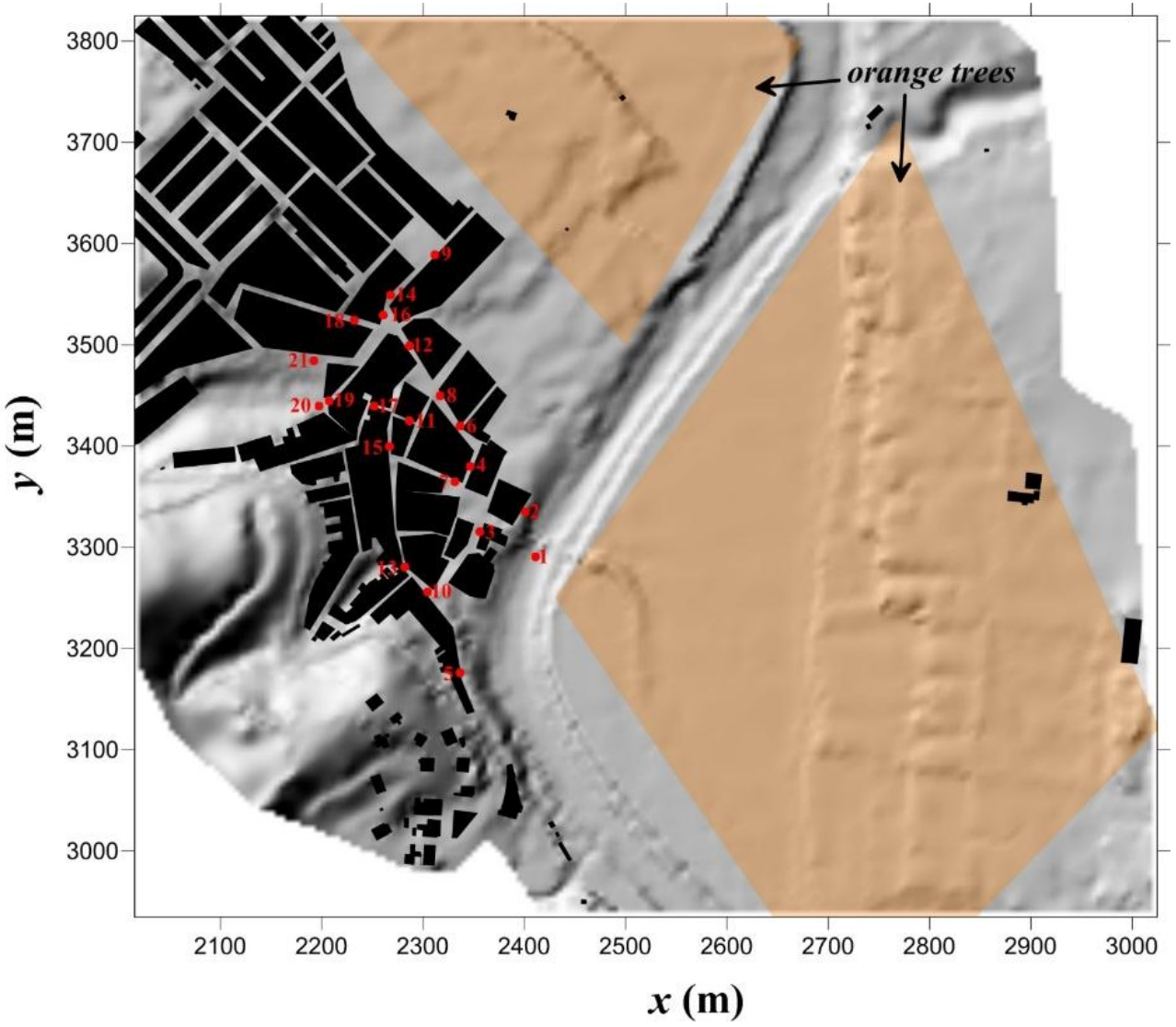
Posing the problem

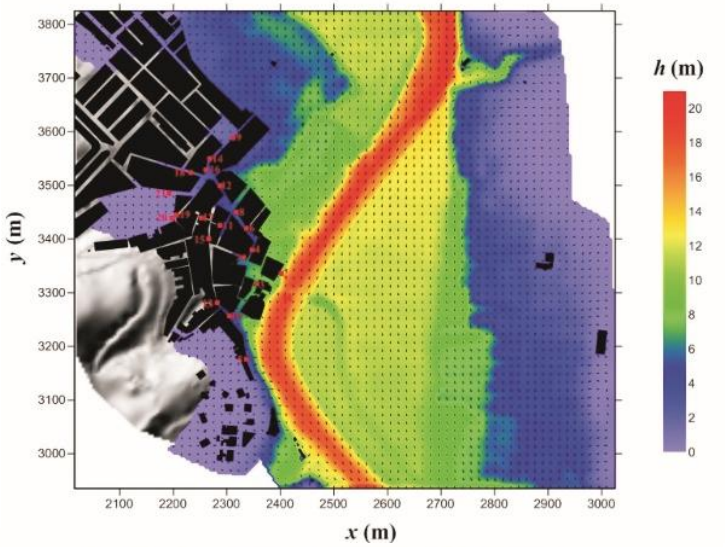
- Developing an emulator system
  - flood warning after a dam break
  - 2D hydrodynamic simulator → FLOW-R2D model
- No measurements
  - three-input emulator
- Measurements
  - two-input emulator → calibration
  - one-input emulator → prediction

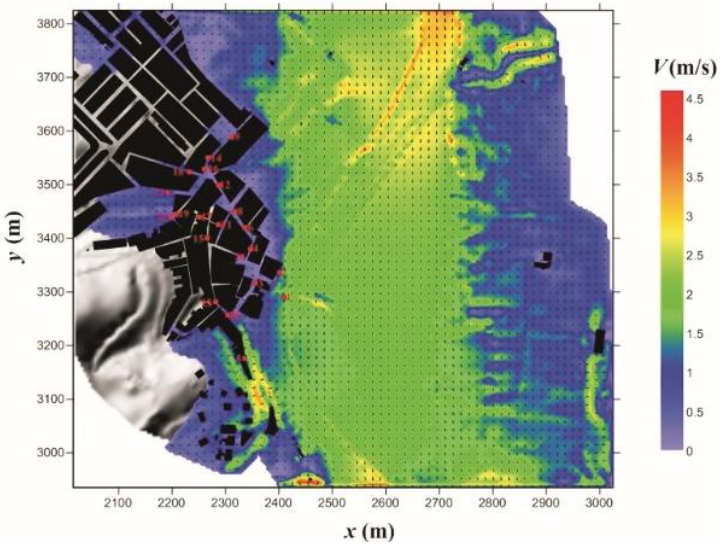
FLOW-R2D model

- 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
- Representation of buildings → solid boundaries

Example


orange trees
y (m)
x (m)
3800
3700
3600
3500
3400
3300
3200
3100
3000
2100
2200
2300
2400
2500
2600
2700
2800
2900
3000


h (m)
y (m)
x (m)
20
18
16
14
12
10
8
6
4
2
0


V(m/s)
y (m)
x (m)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0

No measurements

- Gaussian Process
- Three-input emulator
  - inflow → 10000 – 20000 m^3/s
  - Manning coefficient → 0.03 – 0.21 $s/m^{1/3}$
  - effective slope → 0.0001 – 0.02
- Output
  - time response for water levels at critical points
- Training data set → 240 runs (LHS)

Measurements

calibration phase

- Gaussian Process
- Two-input emulator → constant inflow 15000 m^3/s
  - Manning coefficient → 0.03 – 0.21 $s/m^{1/3}$
  - effective slope → 0.0001 – 0.02
- Output
  - water depth after convergence
- Training data set → 150 runs (LHS)

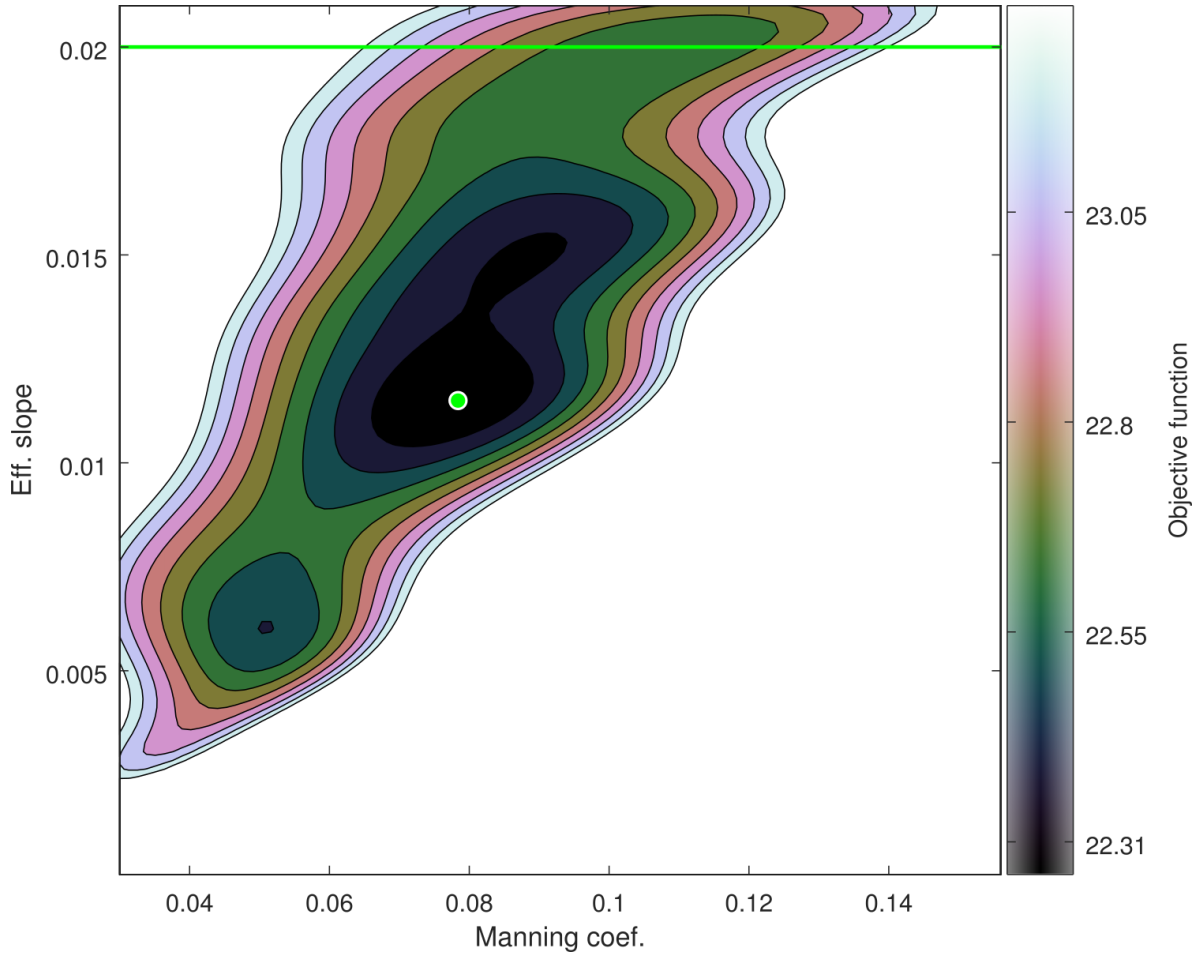
Measurements

prediction phase

- Spline interpolation
- One-input emulator → calibrated parameters
  - inflow → 10000 – 20000 m^3/s
- Output
  - time response for water levels at critical points
- Training data set → 100 runs (uniform sampling)

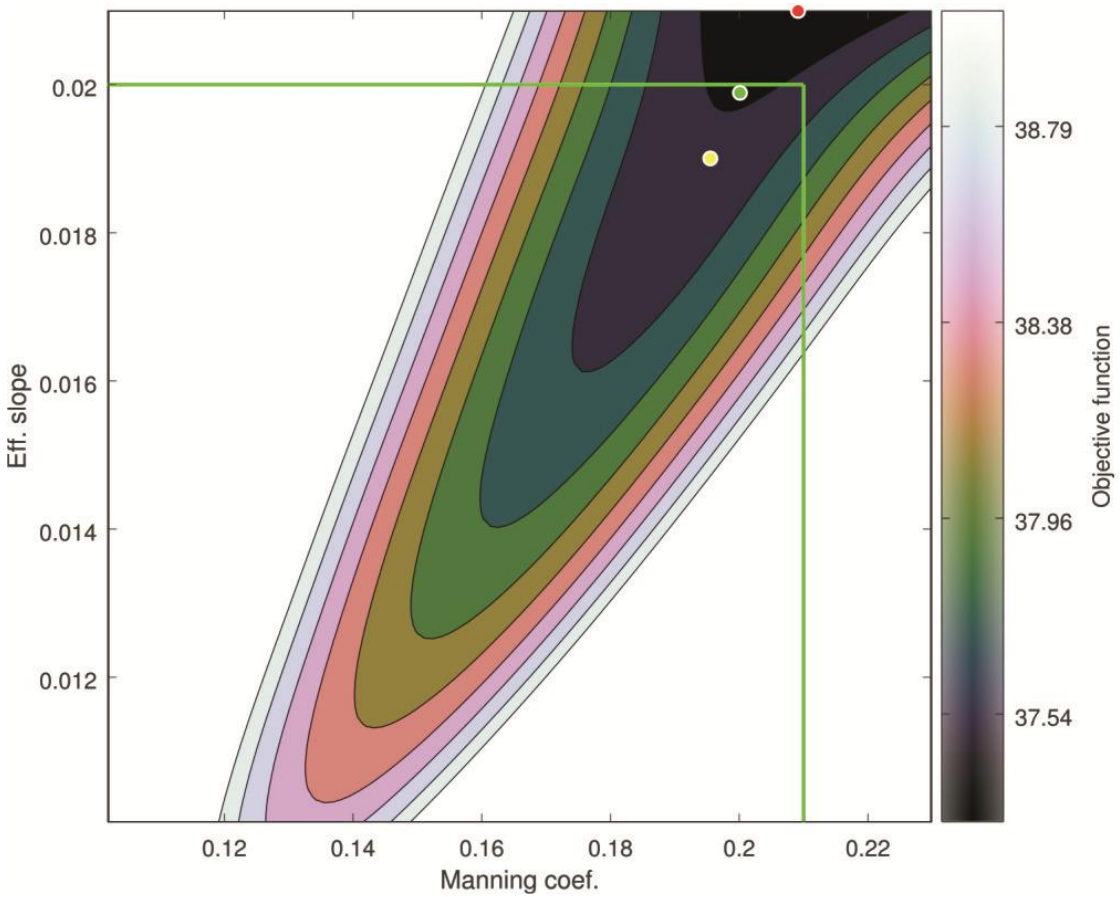
Calibration phase

3-input emulator



Calibration phase

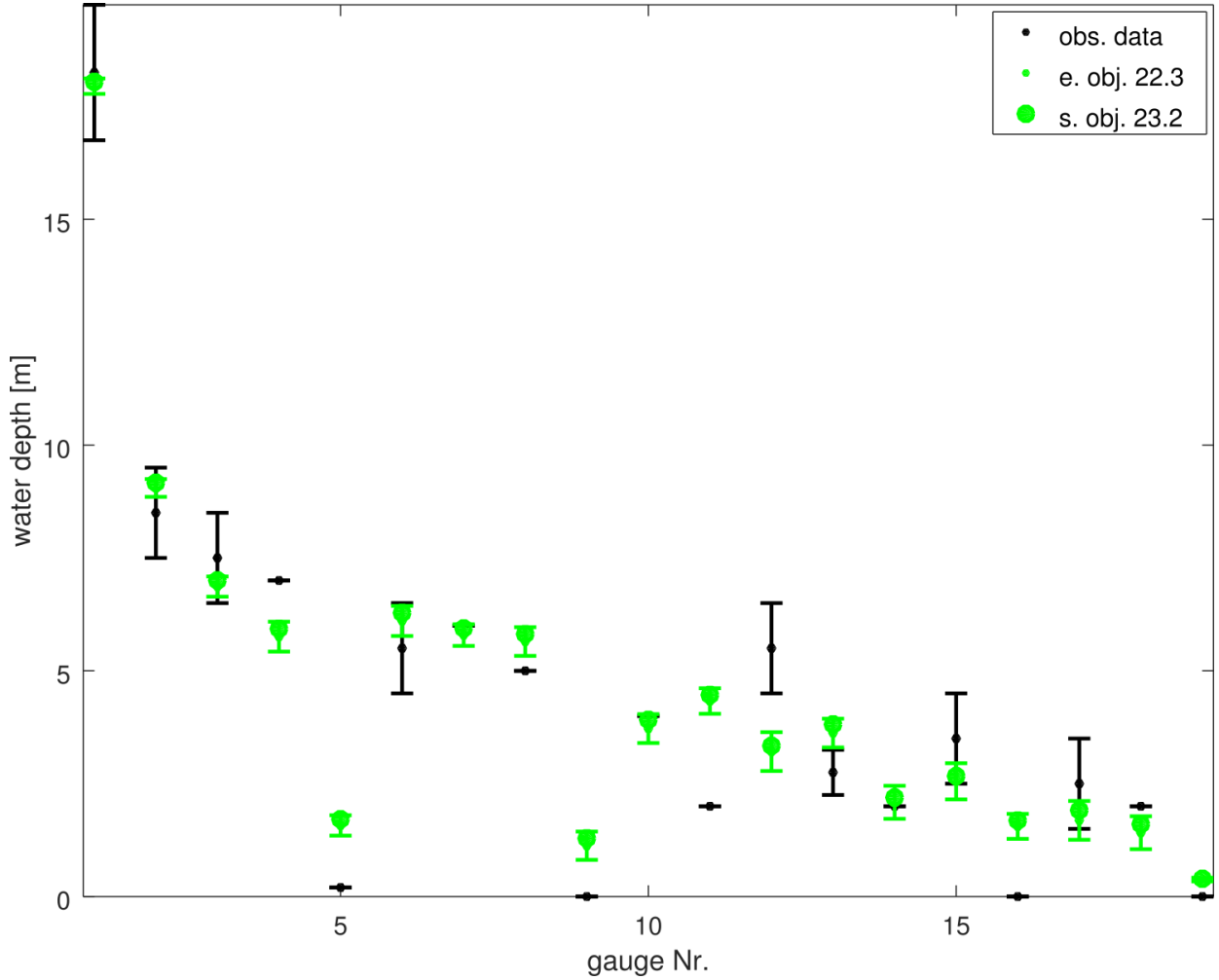
2-input emulator



- extrapolation
- intrapolation
- previous attempt

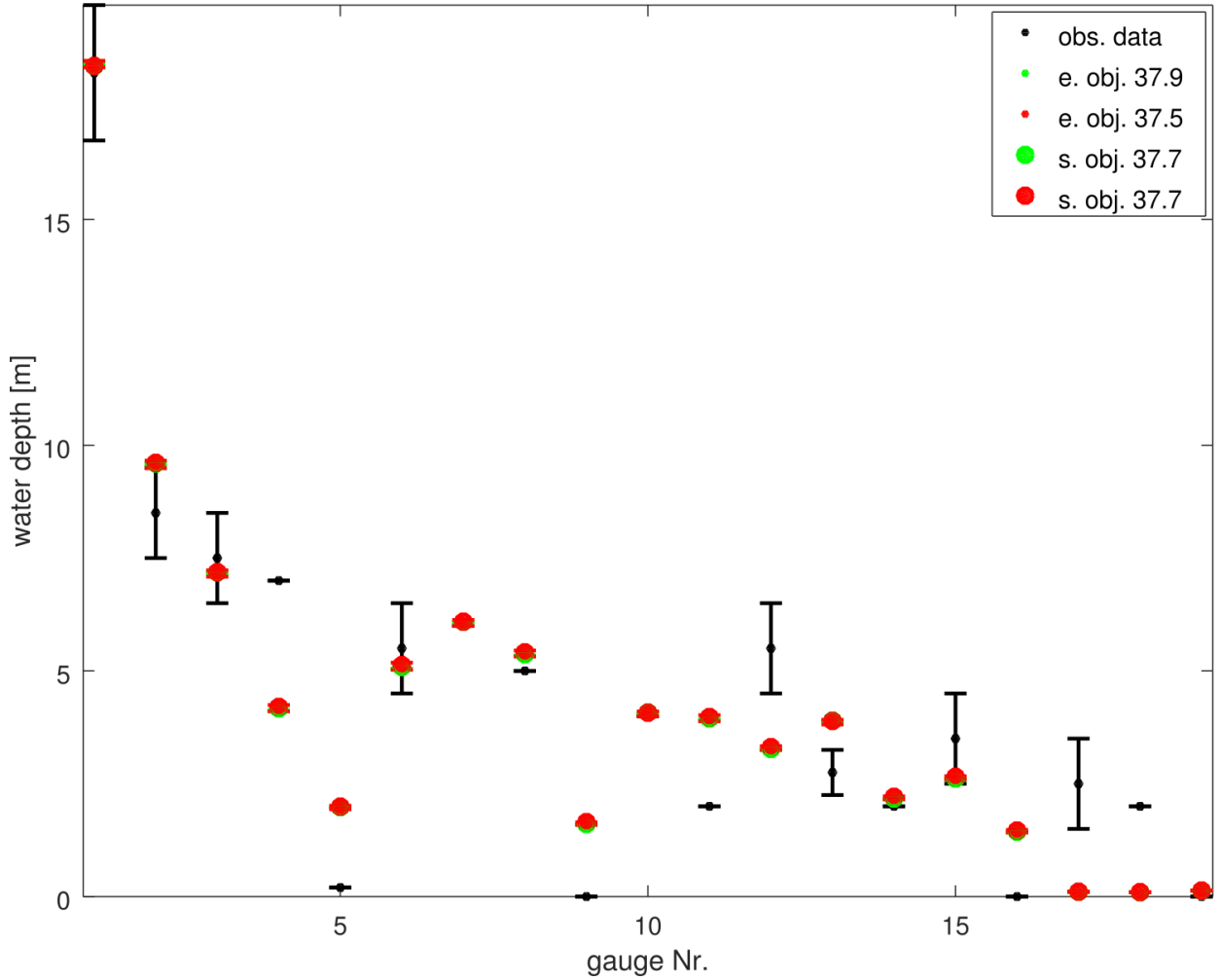
Validation phase

3-input emulator



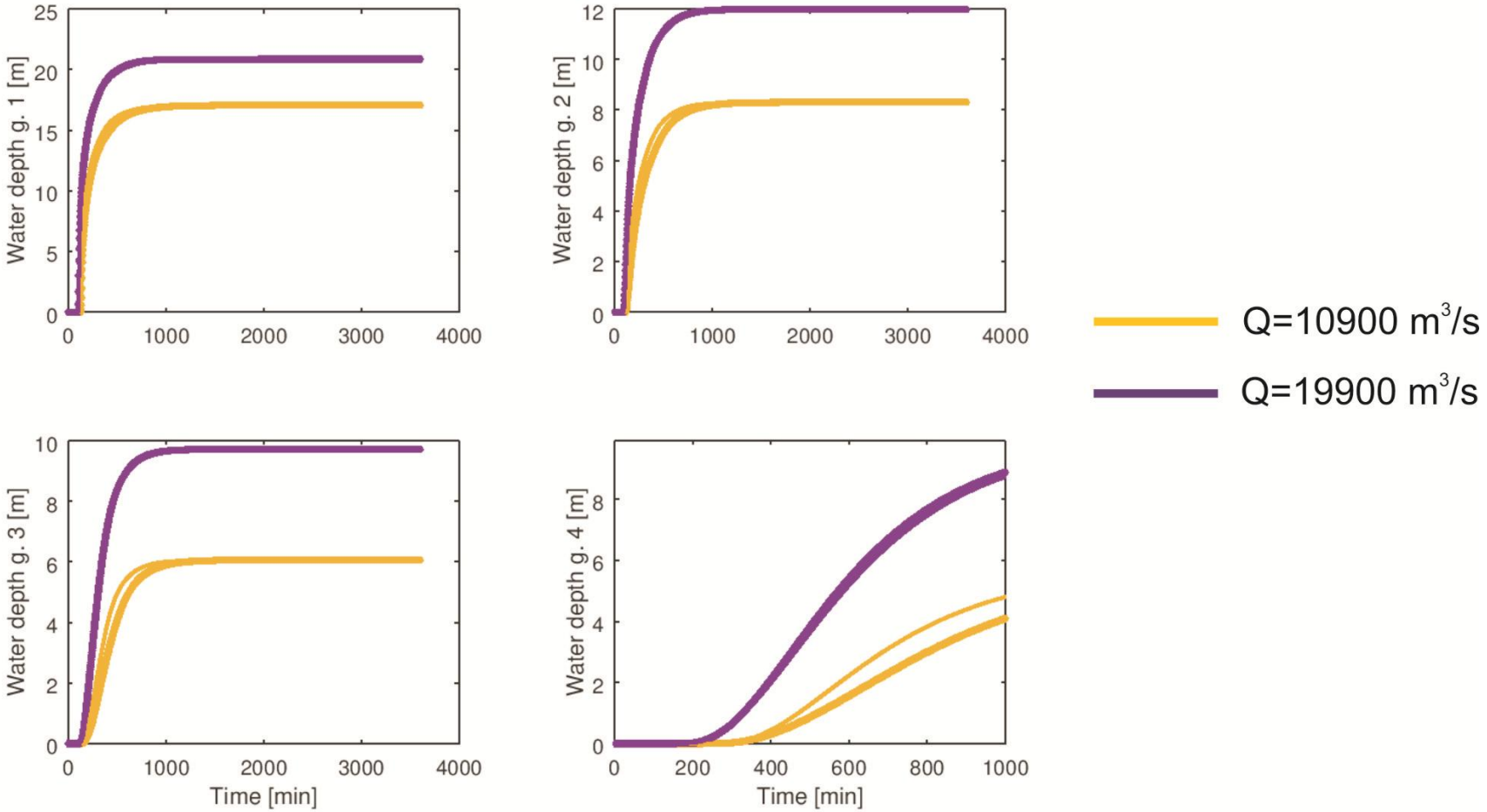
Validation phase

2-input emulator



Response time

1-input emulator



Conclusion

- Three-input emulator
  - no measurements required
  - adaptive tool for calibration, uncertainty quantification etc.
  - less accurate results
  - larger sample of runs
- Combining two-input with one-input emulator
  - requires measurements
  - non-adaptive tool
  - more accurate results
  - less sample of runs

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