Updating of a conceptual urban drainage model for online operation

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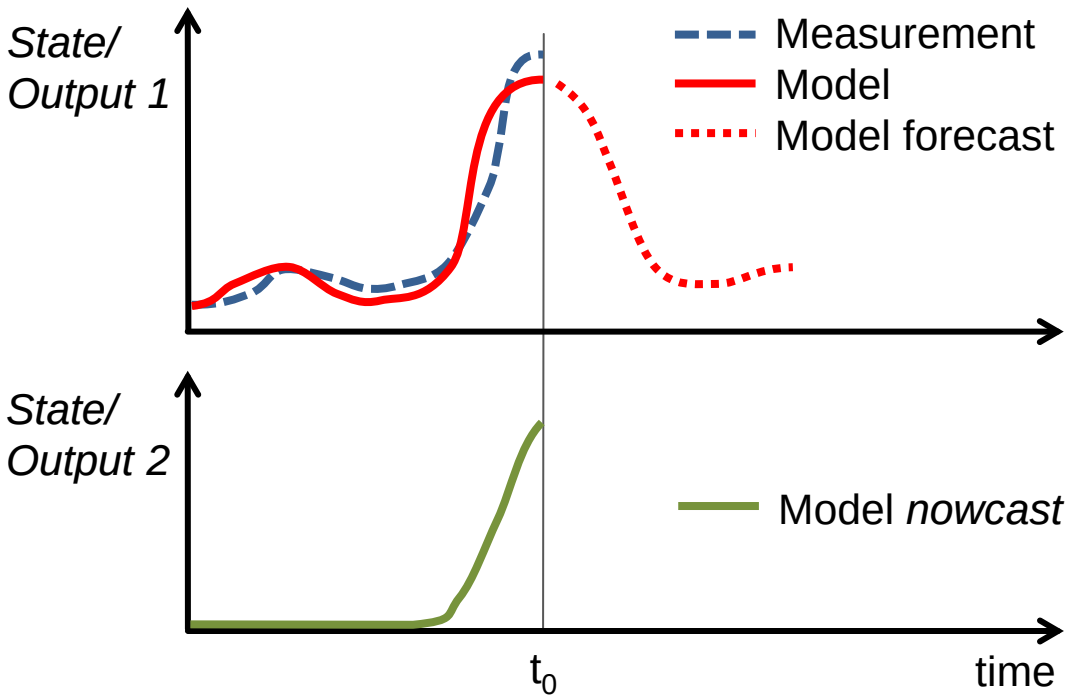
9th UDM Conference, Belgrade

September 5, 2012

Online simulation models

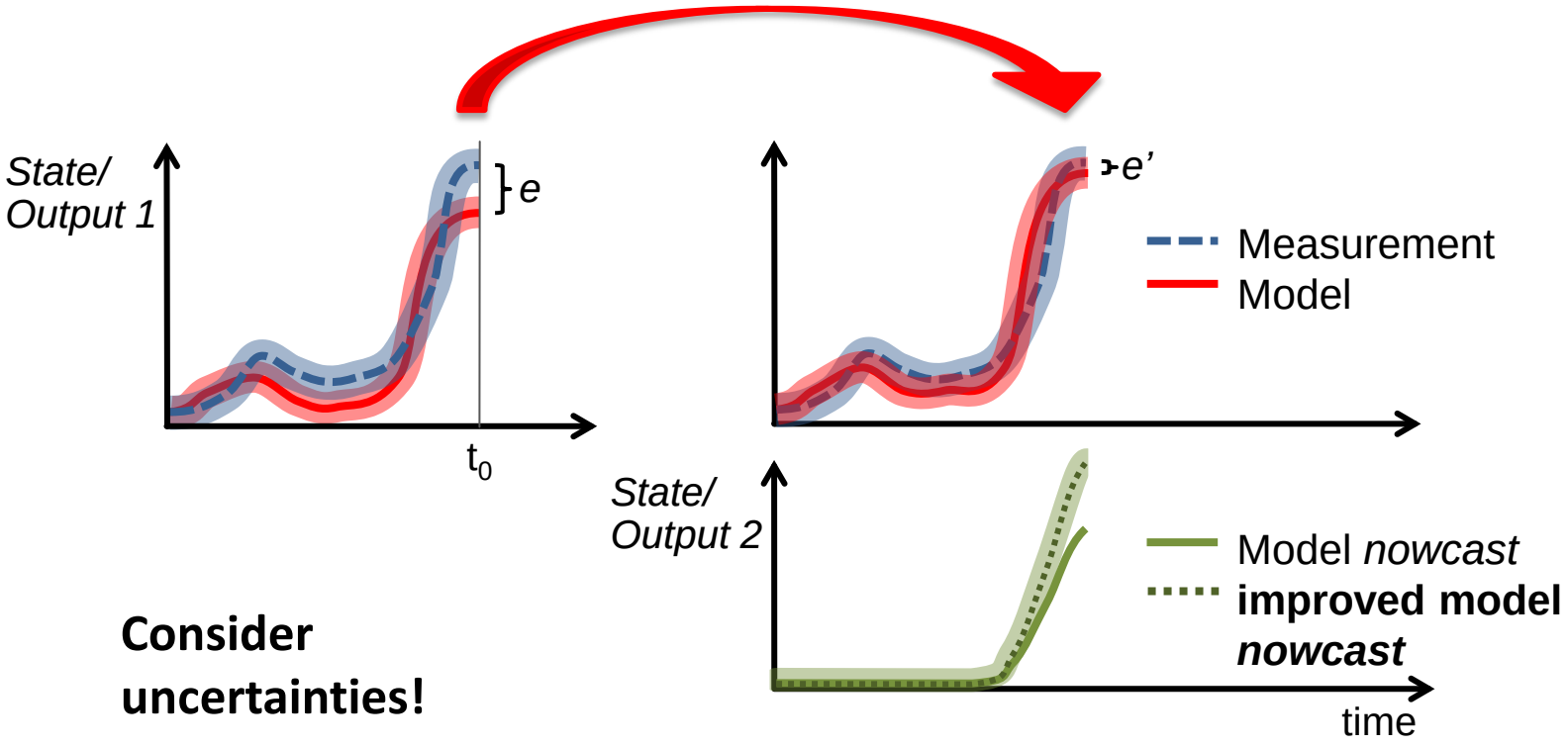
- forecast models (RTC, ...)
- **software sensors** (*nowcast* models)

  ⇨ provide information not measured by real sensors



Model updating

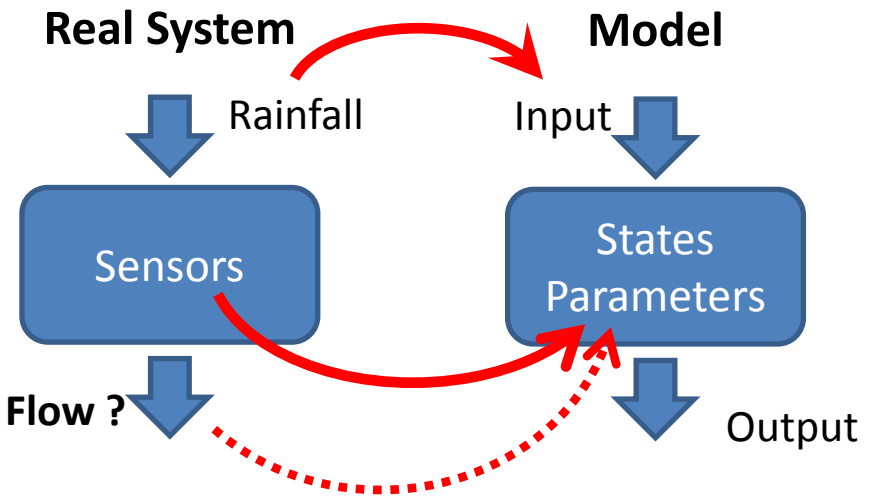
Model Updating ⇨ improve nowcast (or forecast)



Consider uncertainties!

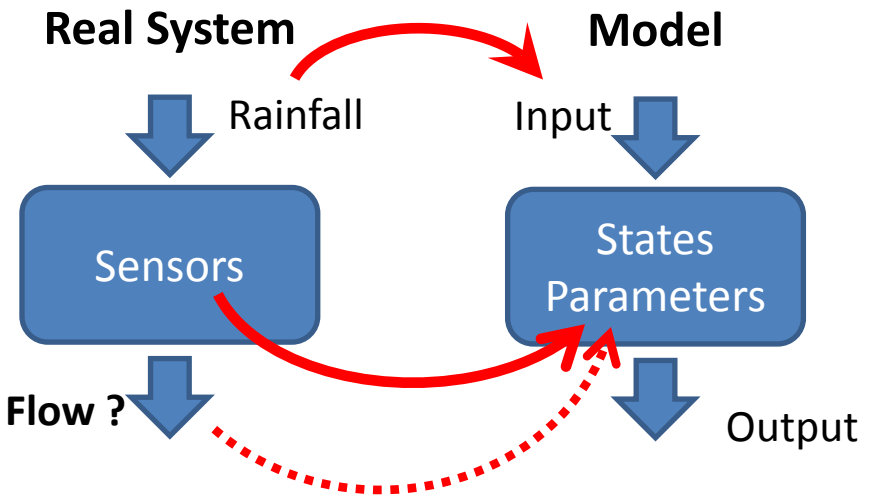
Model Updating

- Updating of ...
  - distributions of model states
    - complex hydrological models
  - distributions of model parameters
  - both



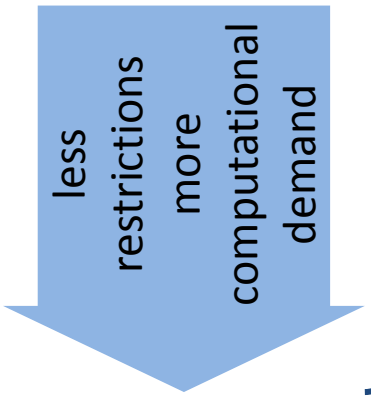
Model Updating

- Updating of ...
  - distributions of model states
    - complex hydrological models
  - **distributions of model parameters**
  - both



Classical methods for model updating

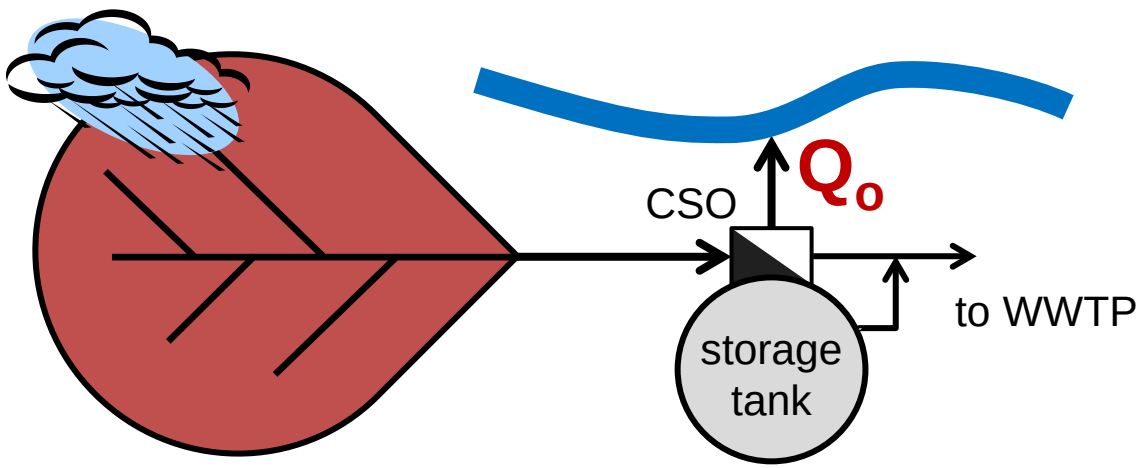
- Kalman filter
- Extended Kalman filter
- Ensemble Kalman filter
  - Monte Carlo simulation
- Particle filter
  - Monte Carlo simulation



application of Bayesian theorem

- Deterministic updating
- ...

Case study



- Simulate overflow Q_o
- Update model parameters
  - ⇨ A_e and t_c
  - ⇨ using “standard” water level data
- Estimate uncertainty of Q_o

Catchment:

- A_{imp}= 9.6ha
- V_s = 240m3
- $Q_{max,WWTP}$ = 0.02m3/s

Online data:

- rainfall (input)
- water level
- overflow (evaluation)

Model concept

- time area method
  - parameters
    - A_e
    - t_c

Updating algorithm

- Event based approach
- Monte Carlo simulations
- Distribution update using GLUE (Beven & Binley, 1992)
- Dynamic adaptation of MC samples

Updating algorithm

- **Event based approach**
- **Monte Carlo simulations**
- Distribution update using GLUE (Beven & Binley, 1992)
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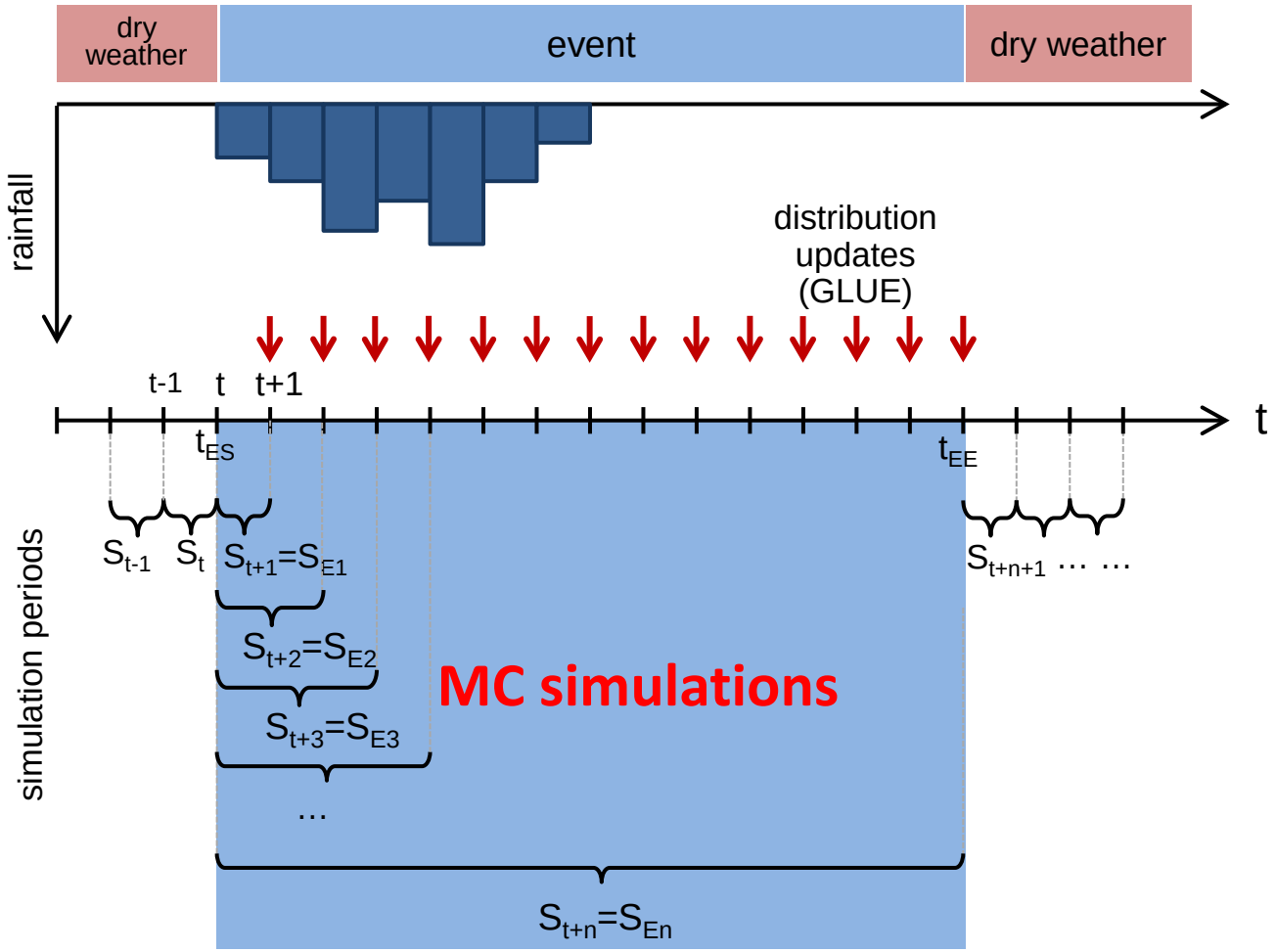
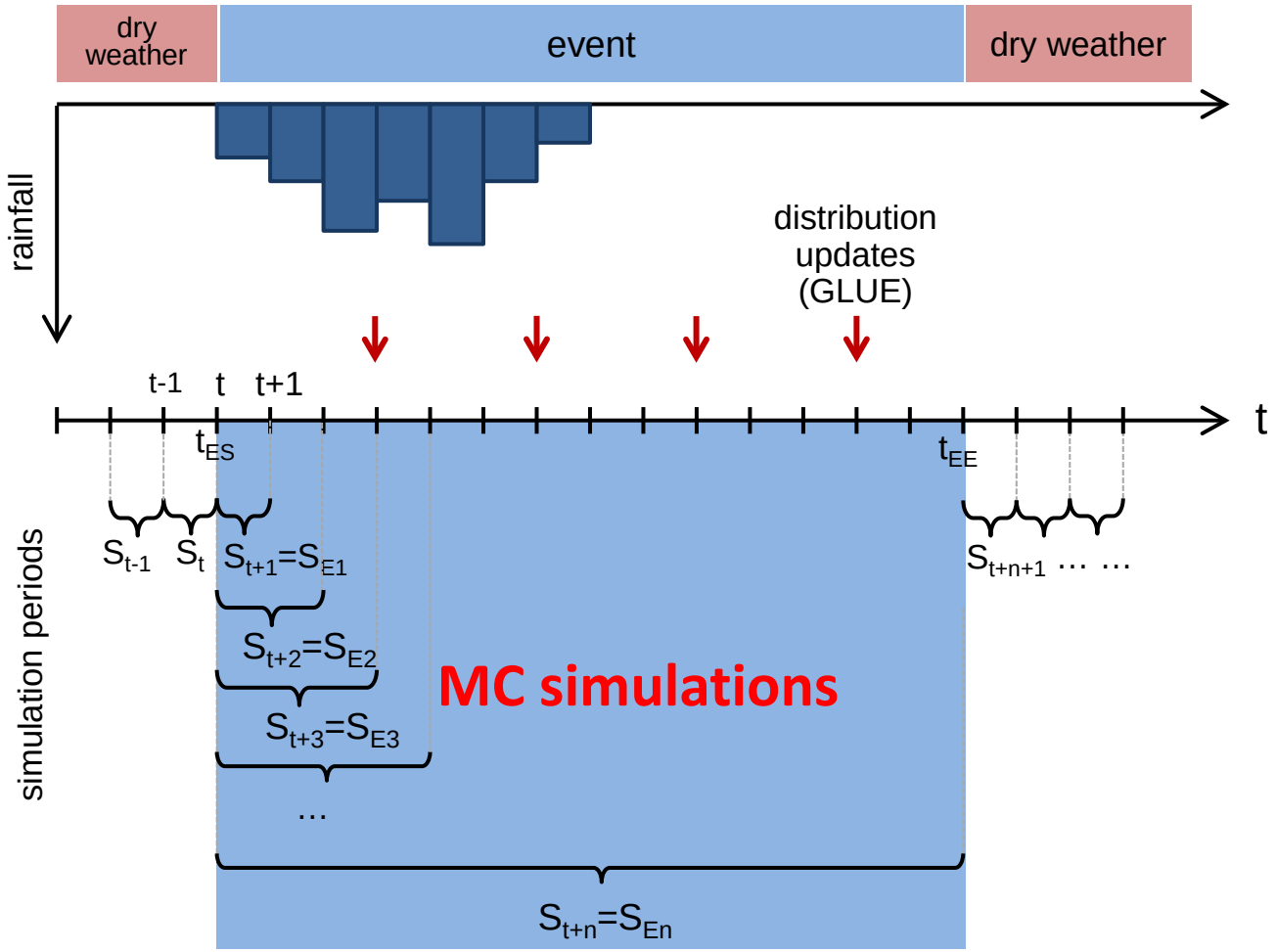
Event based updating algorithm



Event based updating algorithm



Updating algorithm

- Event based approach
- Monte Carlo simulations
- **Distribution update using GLUE** (Beven & Binley, 1992)
- Dynamic adaptation of MC samples

Distribution update

- Online water level data ⇨ **overflow YES/NO**

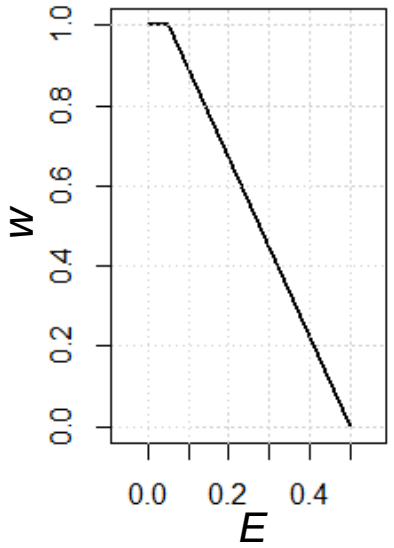
$$h_{obs} \rightarrow q'_{obs} = 0, 0, 0, 1, 0, 1, 1, 1, \ldots$$

- Transform simulation results

$$q_{sim} \rightarrow q'_{sim} = 0, 0, 1, 0, 0, 1, 1, 1, \ldots$$

- Objective function and weighting function

$$E = \frac{\sum_{i=1}^{n_e} \left| q'_{sim,i} - q'_{obs,i} \right|}{n_e}$$



n_e: length of time series

$E \geq 0$, samples accepted if $E < 0.5$

Updating algorithm

- Event based approach
- Monte Carlo simulations
- Distribution update using GLUE (Beven & Binley, 1992)
- **Dynamic adaptation of MC samples**
  - consecutive simulation of e.g. 250 samples
  - Kolmogorov-Smirnov test

Simulation experiments

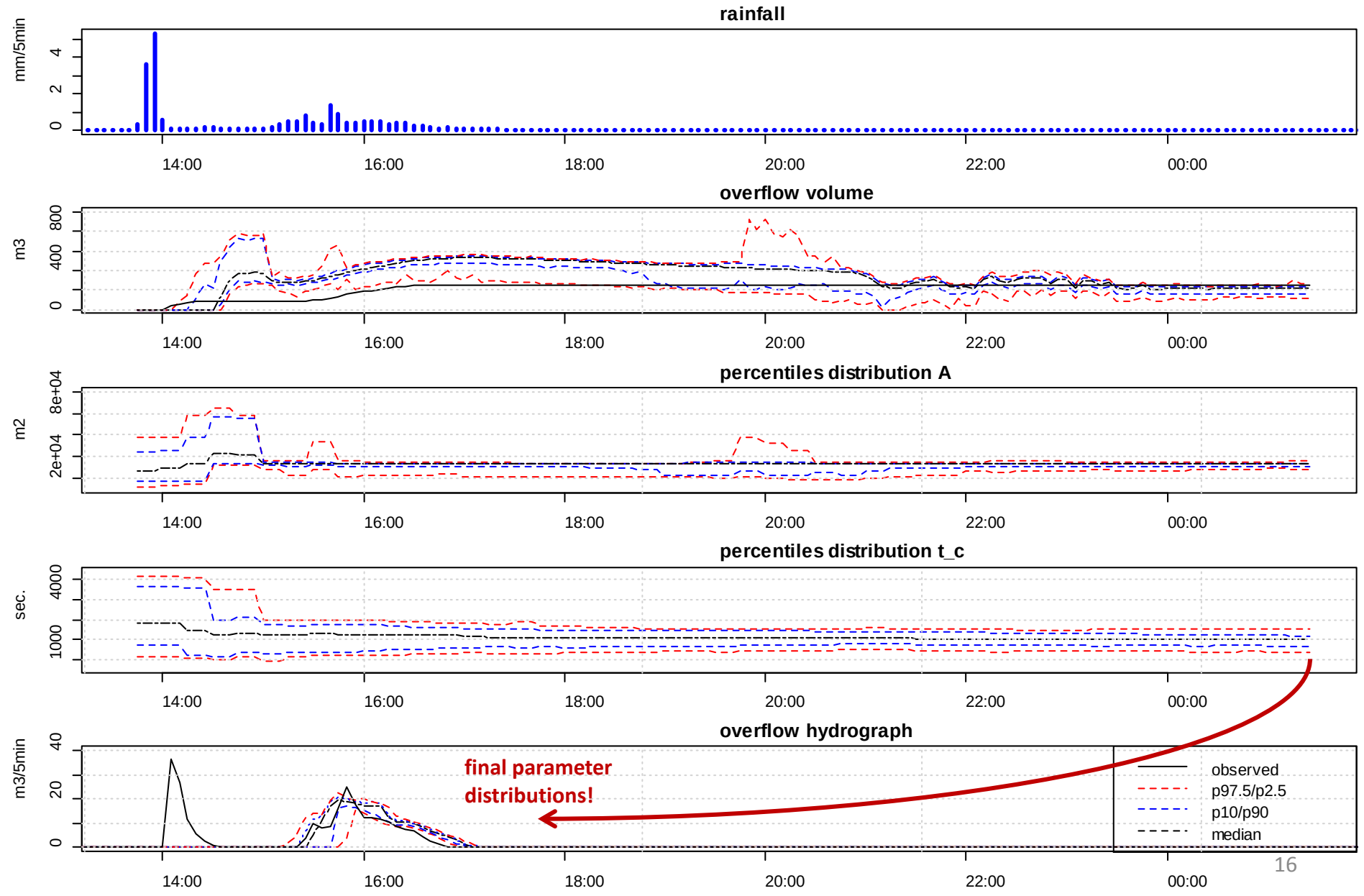
- Test periods
  - 19 events, 5 with overflow
- Updated parameter distributions
  - A_e and t_c
  - A_e
- Updating intervals
  - 1 time step
  - 3 time steps

⇨ Compare to measurements of overflow

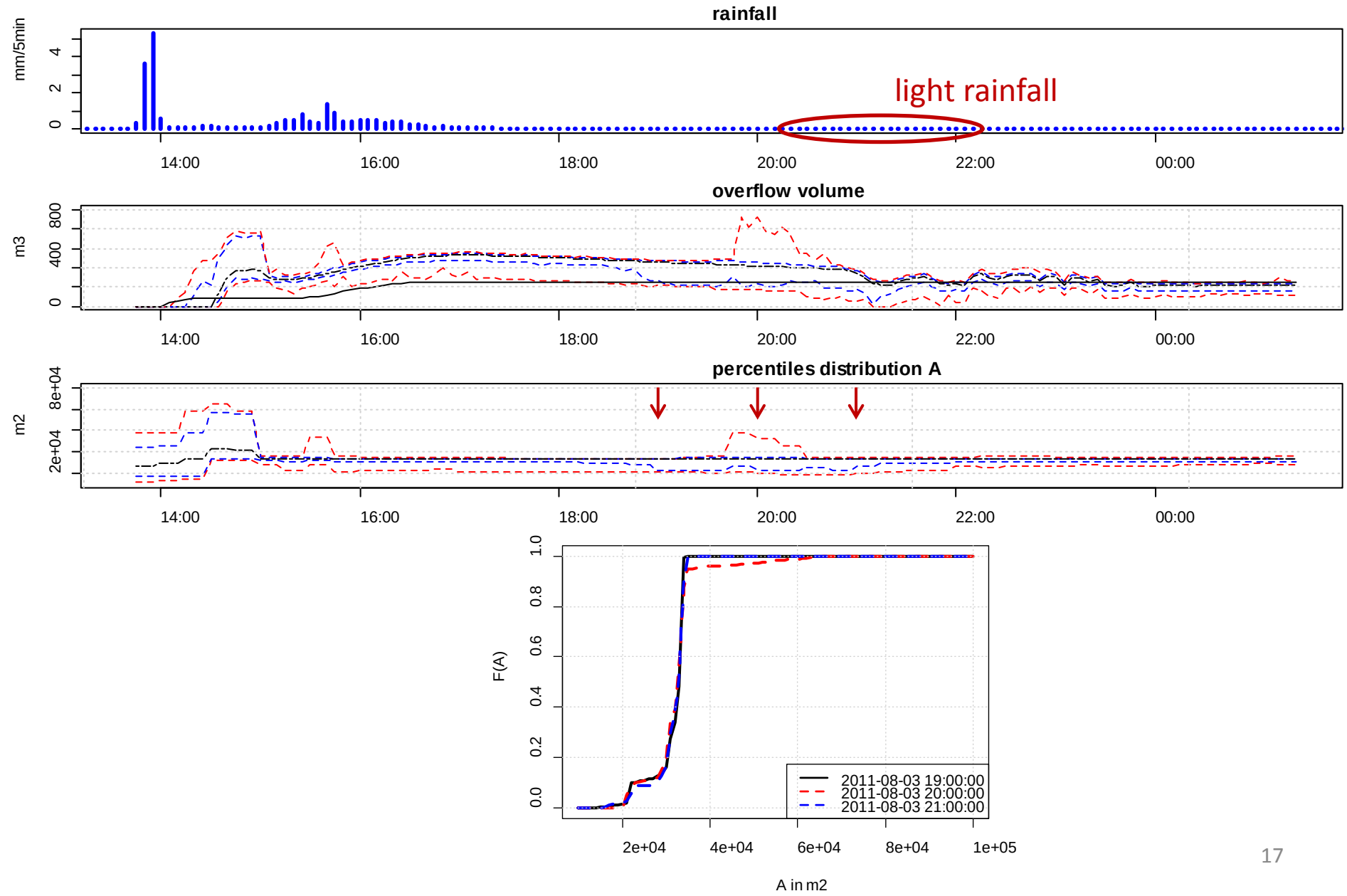
⇨ Compare to forward error estimation

  - MC simulation, 2500 samples

Results (event 12, parameters updated: A_e, t_c, updating interval: 3 time steps)

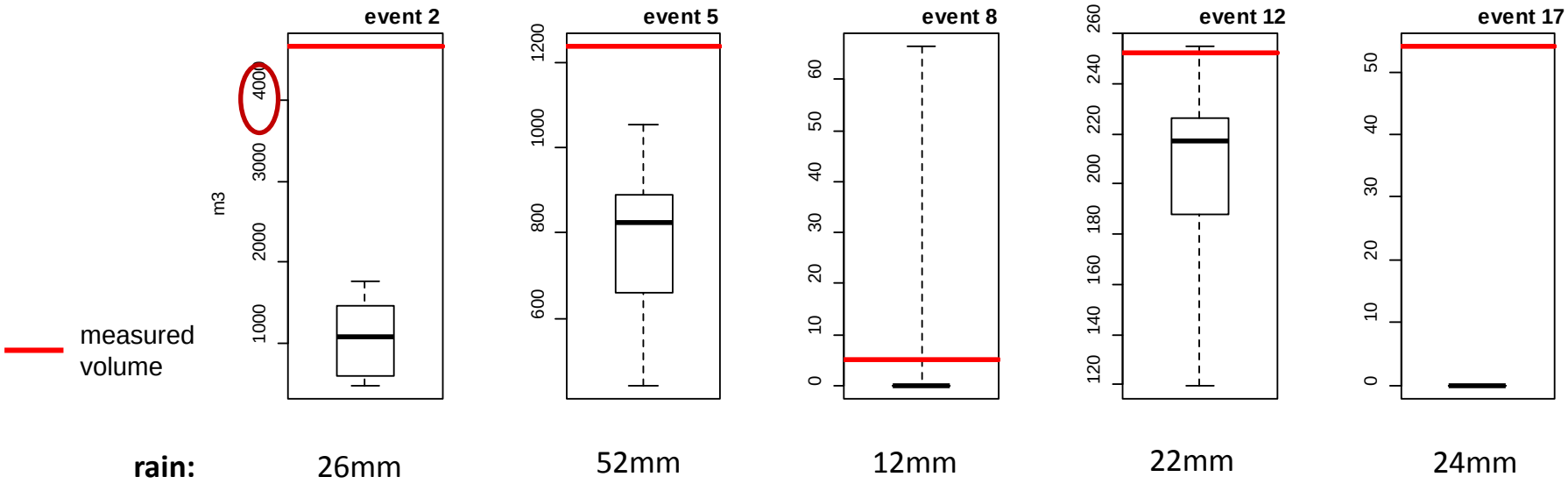


Results (event 12, parameters updated: A_e, t_c, updating interval: 3 time steps)



Results – total overflow volume/event

parameters updated: A_e, t_c
updating interval: 3 time steps



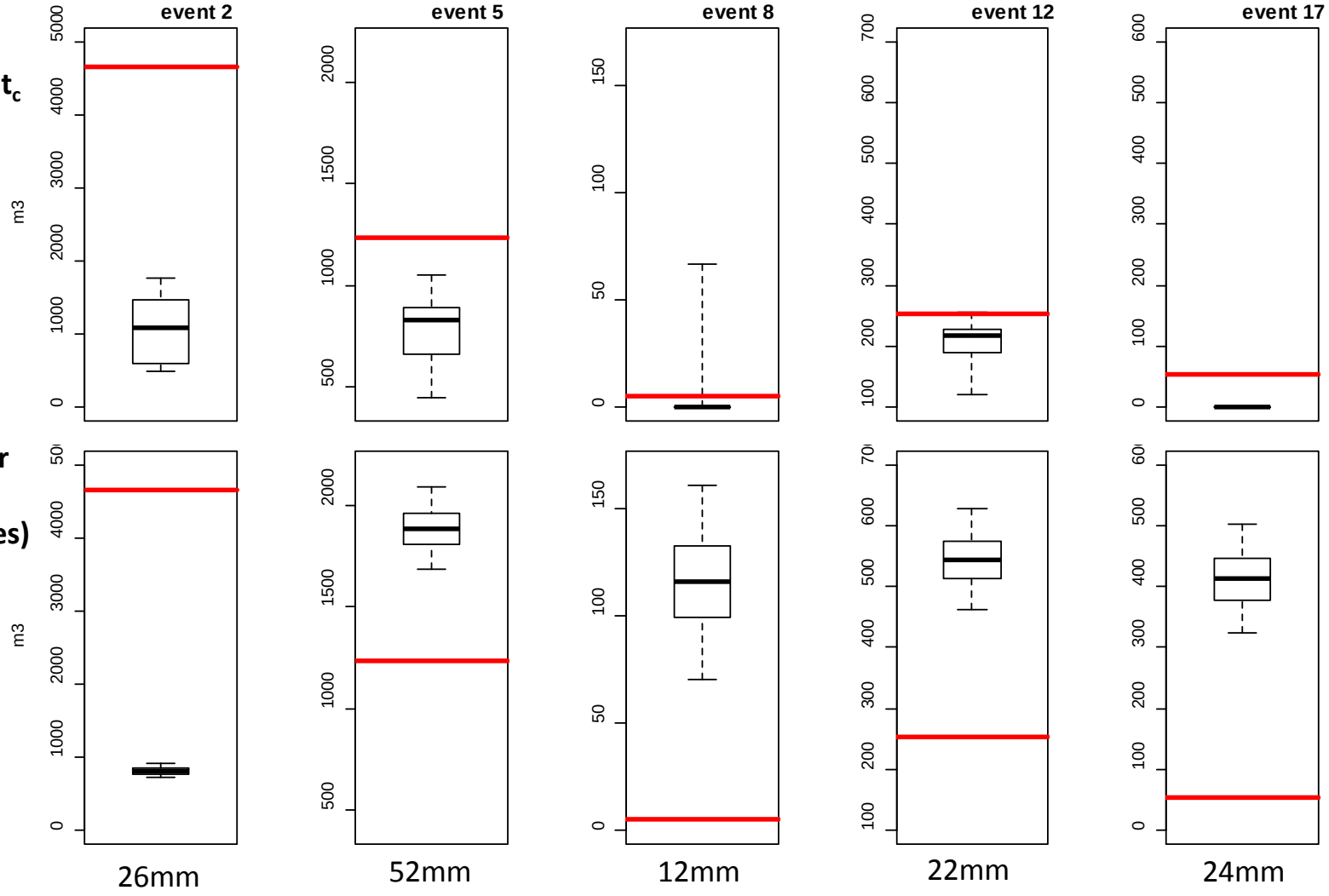
Results – total overflow volume/event

parameters updated: A_e, t_c
interval: 3

measured volume

forward error estimation (2500 samples)

measured volume



Summary and conclusions

- Algorithm to...
  - update parameter distributions of a conceptual model
  - based on surrogate data – measurements of system states
  - improve the model output of interest
  - provide uncertainty estimation
- Main results
  - small improvements - better performance than forward error estimation
  - requires careful choice of algorithm parameters and settings
    - ⇨ test other objective functions and parameters
  - can potentially emphasize
    - erroneous data
    - model structure deficits ⇨ improve model structure

Thank you for your attention!

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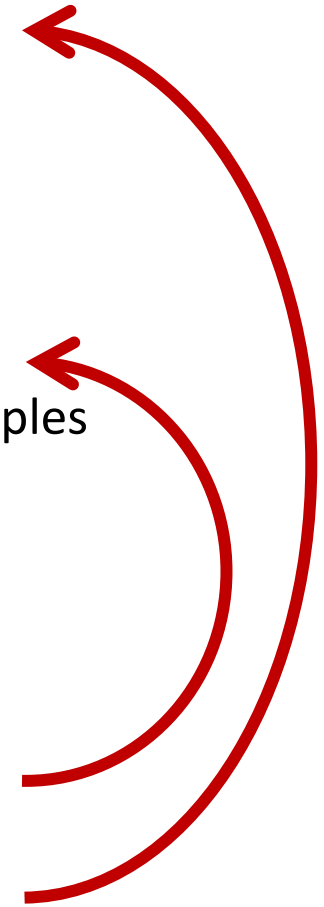
Acknowledgements

Annex

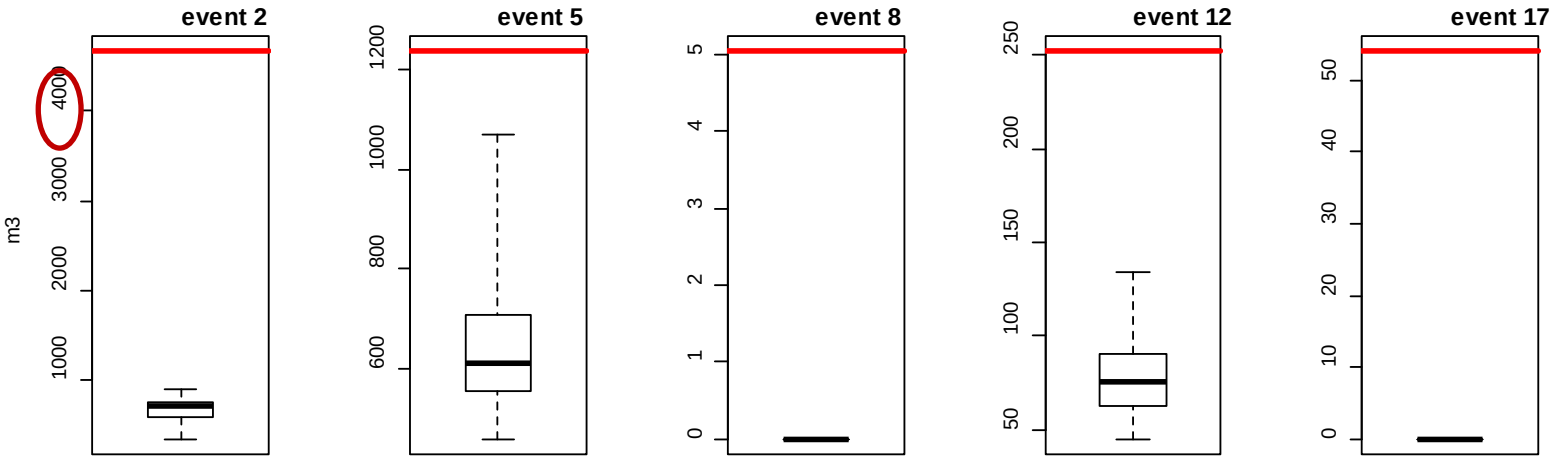
Dynamic adaptation of MC samples

- For each updating time step...
  1. run e.g. 250 samples
  2. evaluate results
  3. update distribution
     ⇒ *Dist_a*
  4. run another 250 samples
  5. update distribution based on all available samples
     ⇒ *Dist_b*
  6. compare *Dist_a* and *Dist_b* using Kolmogorov-Smirnow test
     if H0 rejected & total samples < max samples:
     set *Dist_a = Dist_b*
     repeat steps 4 to 6
     else: proceed to next time step

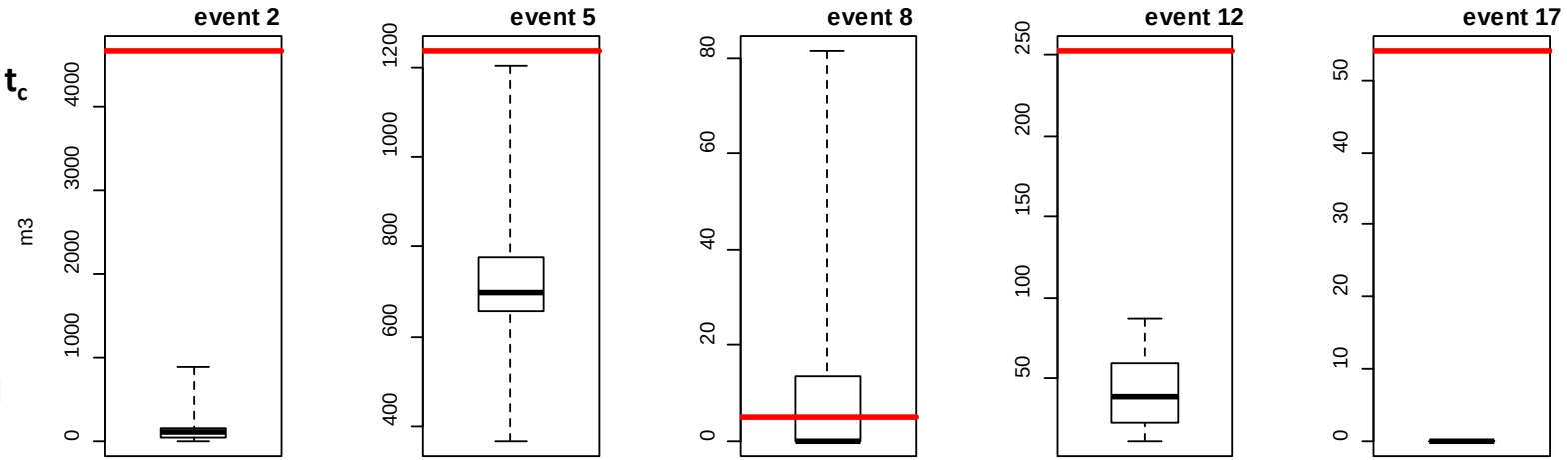


Results – total overflow volume/event

parameters updated: A_e interval: 3



parameters updated: A_e, t_c interval: 1



rain: 26mm | 52mm | 12mm | 22mm | 24mm

Results – total overflow volume/event

parameters updated: A_e
interval: 1