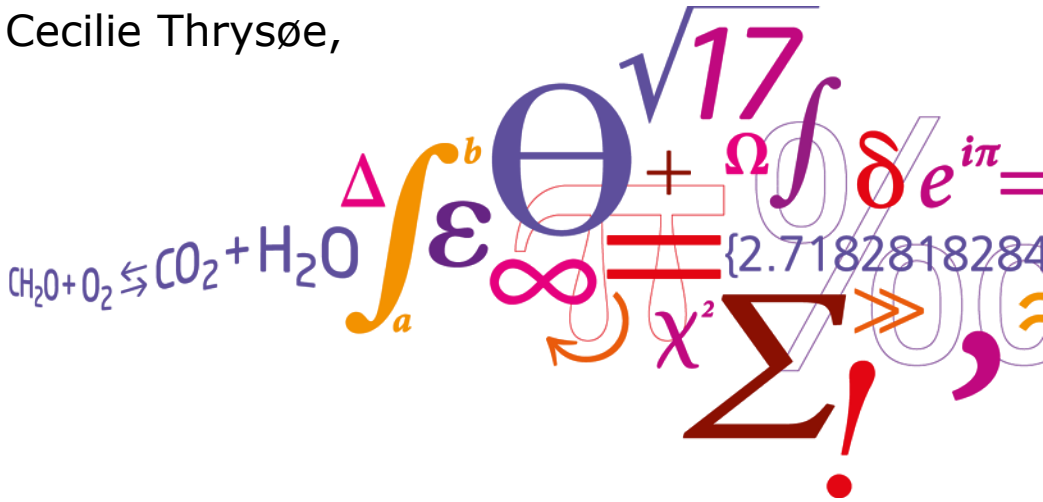
Simplification of one-dimensional hydraulic networks by automated processes evaluated on 1D/2D deterministic flood models

Steffen Davidsen, ***Roland Löwe***, Cecilie Thrysøe,
Karsten Arnbjerg-Nielsen



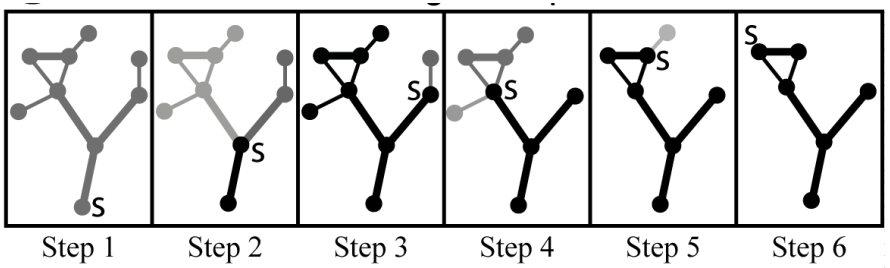
DTU Environment
Department of Environmental Engineering

Purpose

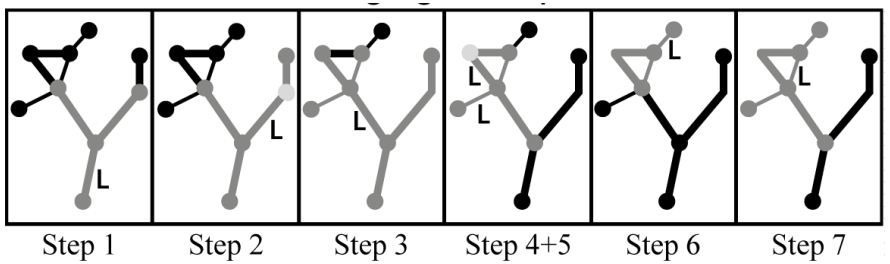
- obtain stable 1D-2D model and reduce simulation times
- work towards standardized way of model reduction
- document effects on simulation results

Algorithm – Trim vs. Merge

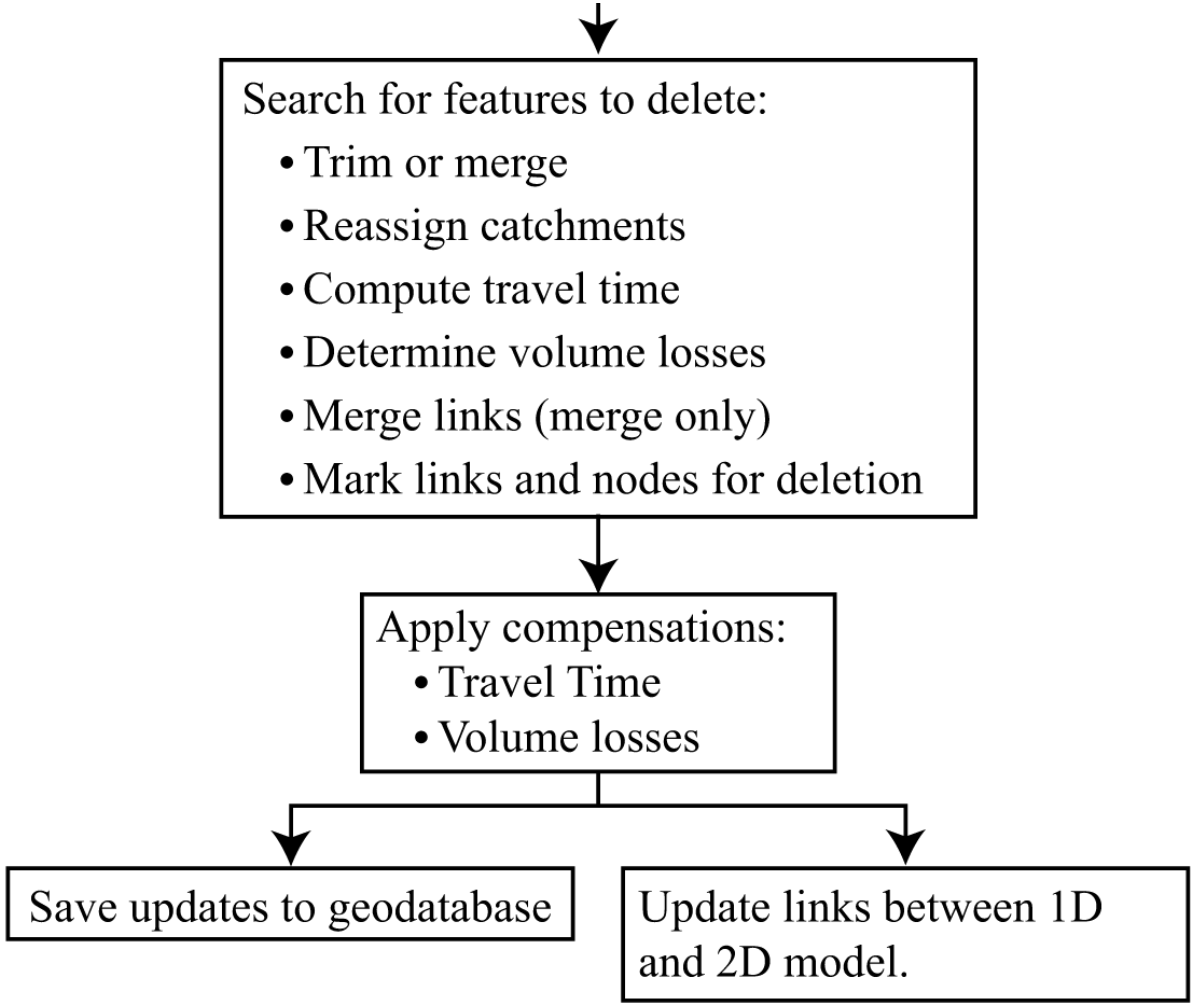
Trim



Merge



Algorithm – Flow Chart



Algorithm – Travel Time Compensation

$v = M \cdot R_h^{\frac{2}{3}} \cdot S^{\frac{1}{2}}$ velocity in deleted pipe

IF $v < 0.15 \frac{m}{s}$ $v = \max(v_{upstream}, 0.15 \frac{m}{s})$

Apply travel time as delay on the rainfall input for each catchment (in increments of 2min)

Algorithm – Volume Compensation

Compute volume of deleted nodes and pipes

Increase downstream node diameter

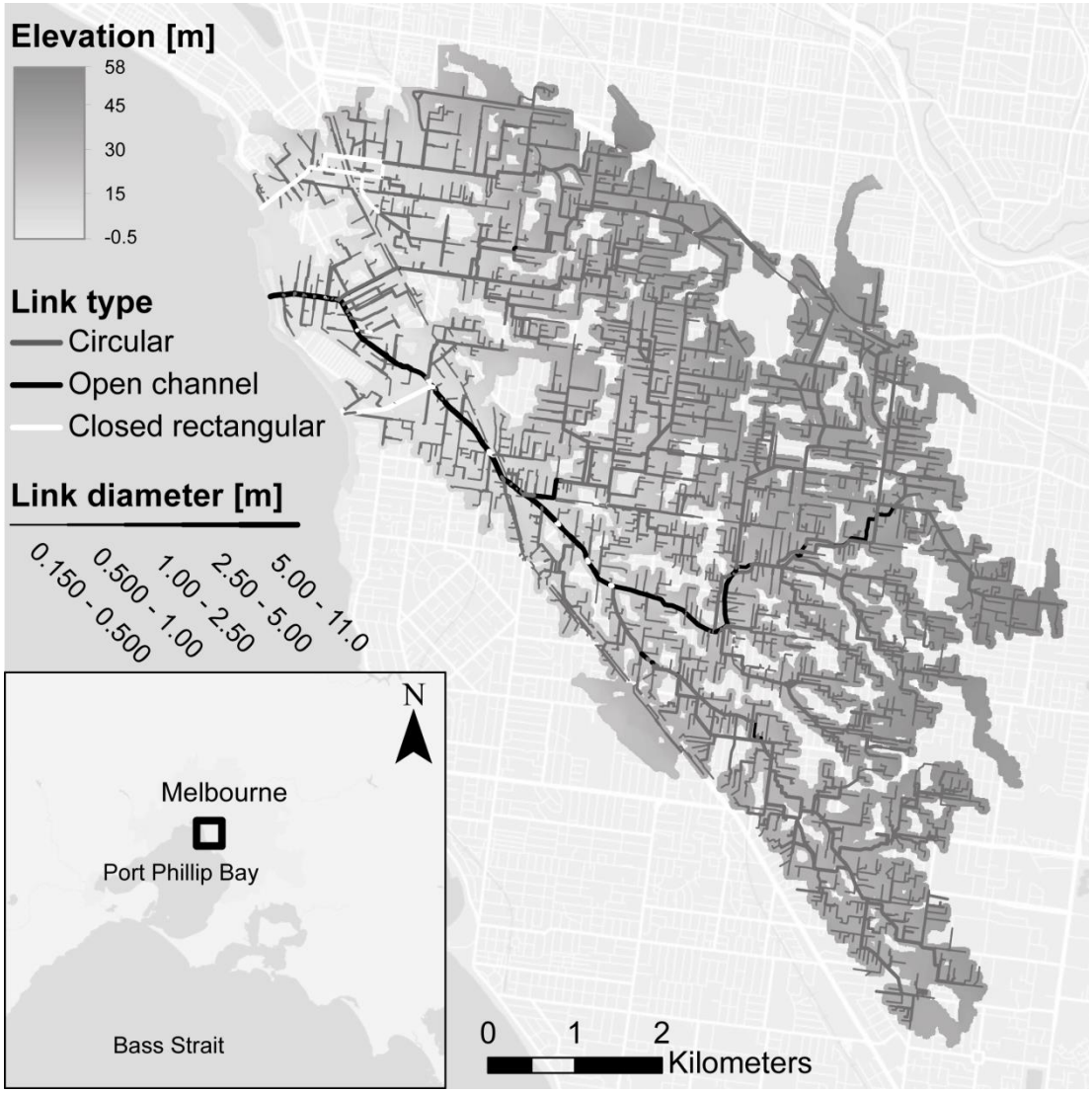
$$D_{new} = \sqrt{\frac{V_{node} + V_{deleted}}{h_{node} \cdot \pi}}$$

Technical Implementation

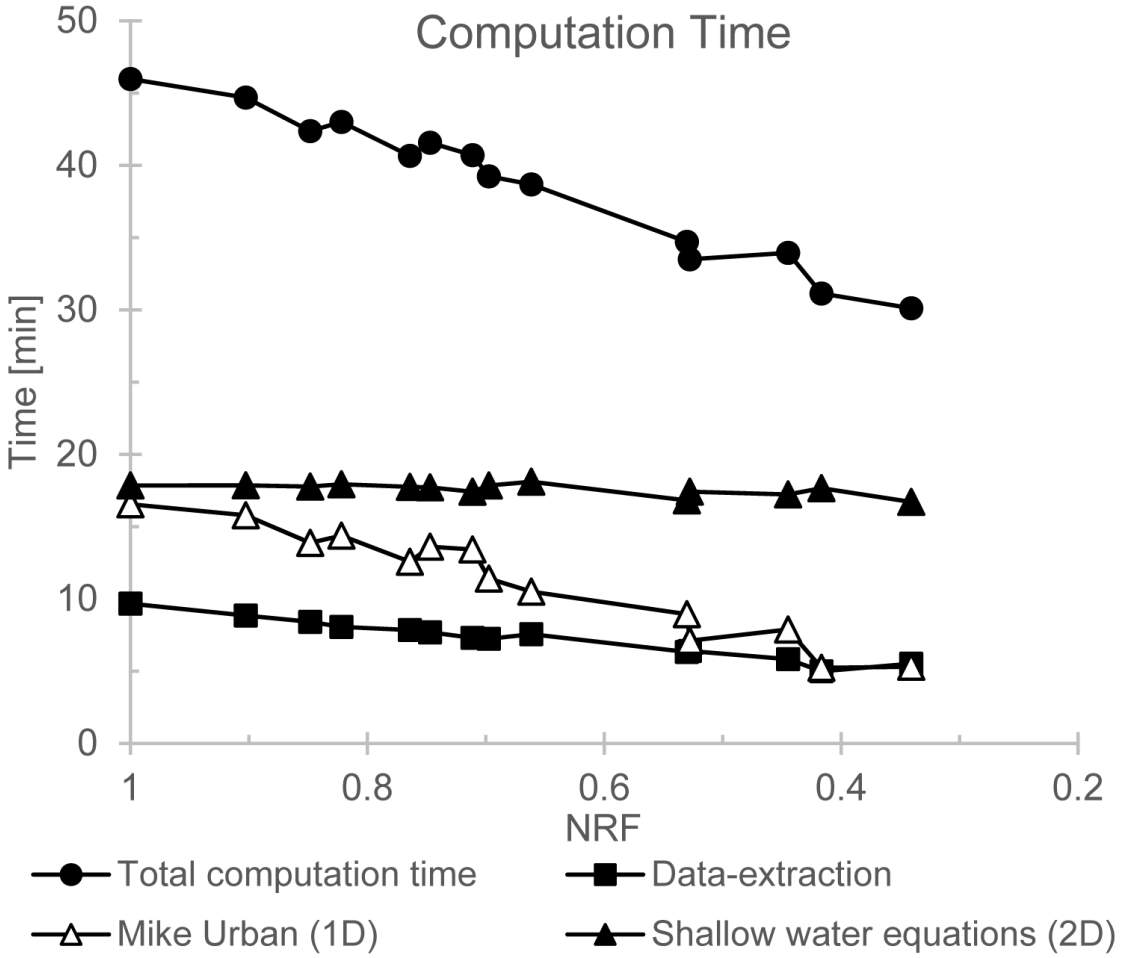
- Python Code
- Perform simplification on arrays describing the network structure
- Update the MIKE Urban database to match the simplified structure
- Update the 1D-2D coupling file

Case

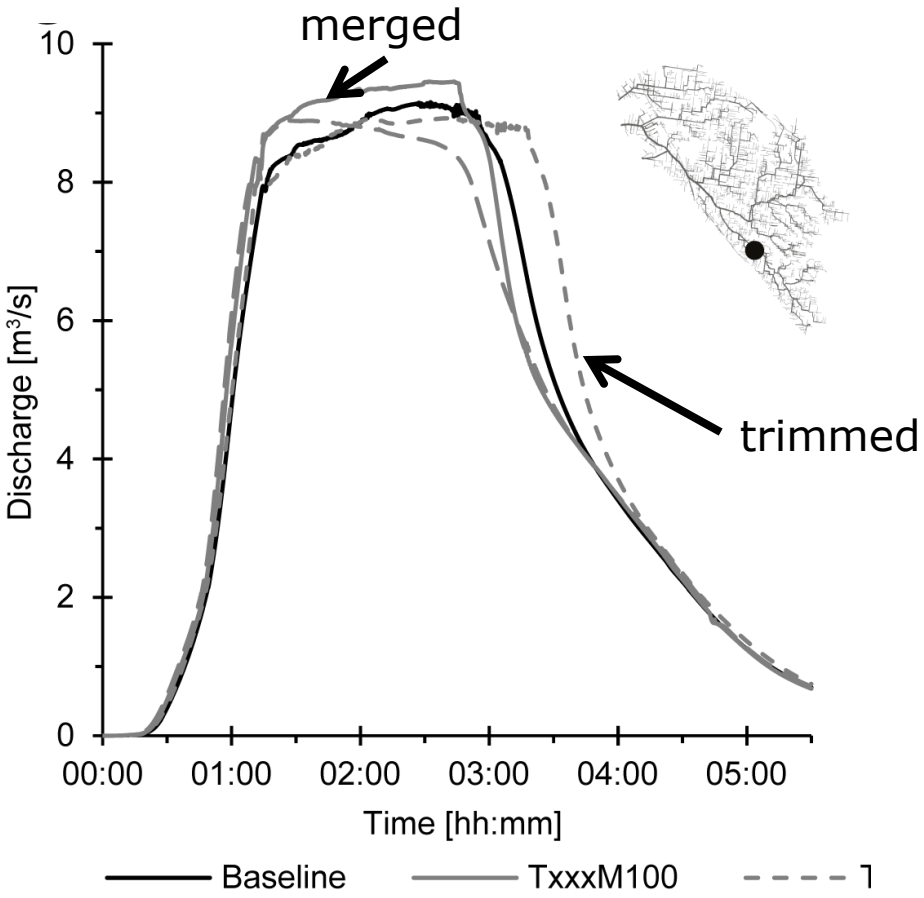
- Elster Creek Catchment
- 45km^2, ~100,000 households
- stormwater network with outlet to the sea, modelled in MIKE 2014 FM
- 11,000 pipes, mesh with 415,000 faces (10x10m)
- simplification takes ~1 minute



Results – Computation Time



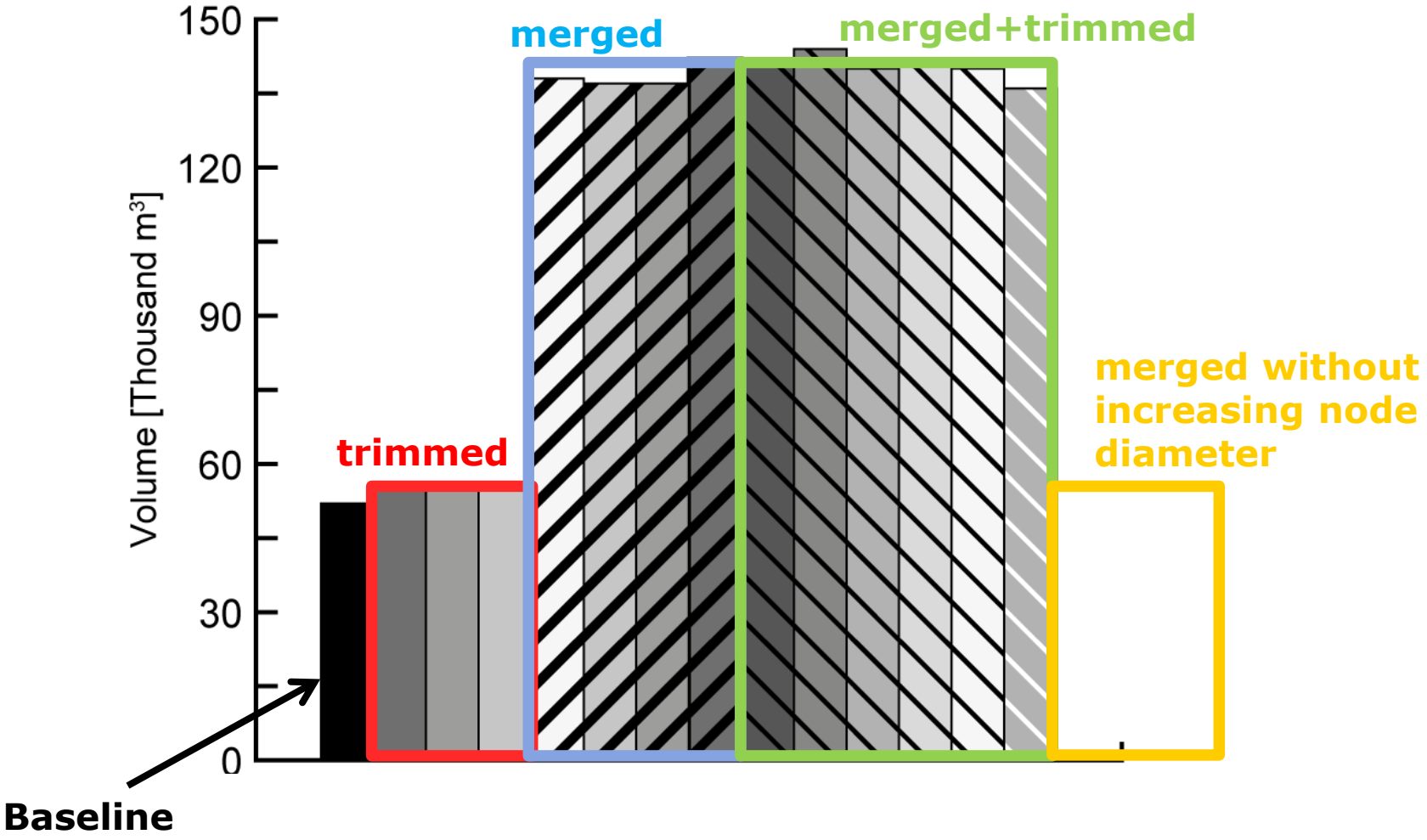
Results - Hydrographs



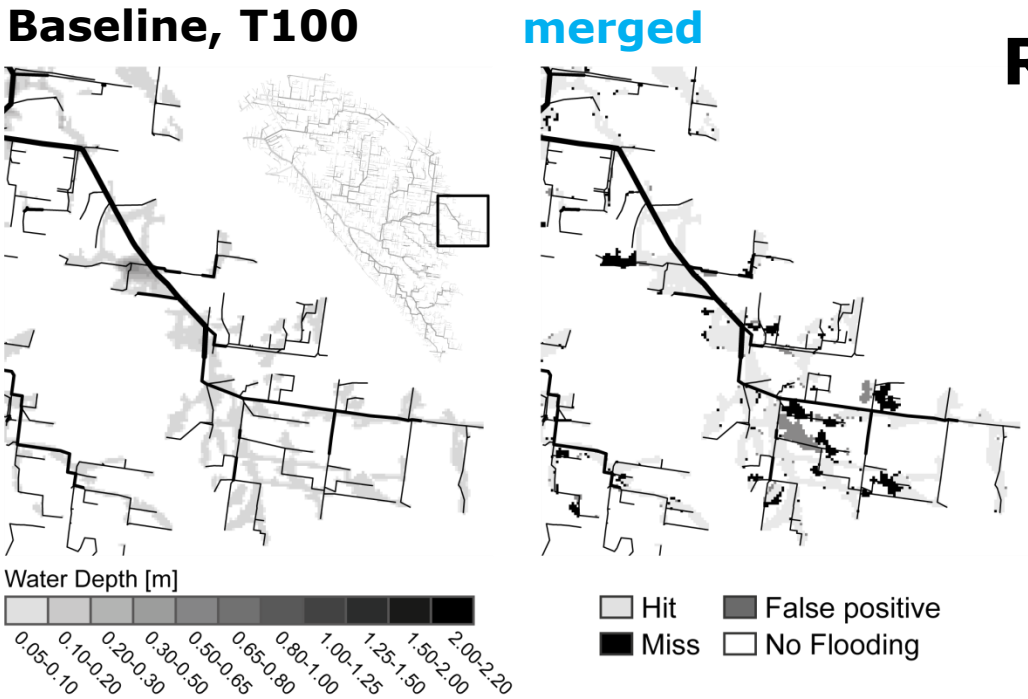
Especially merging leads to higher peaks:

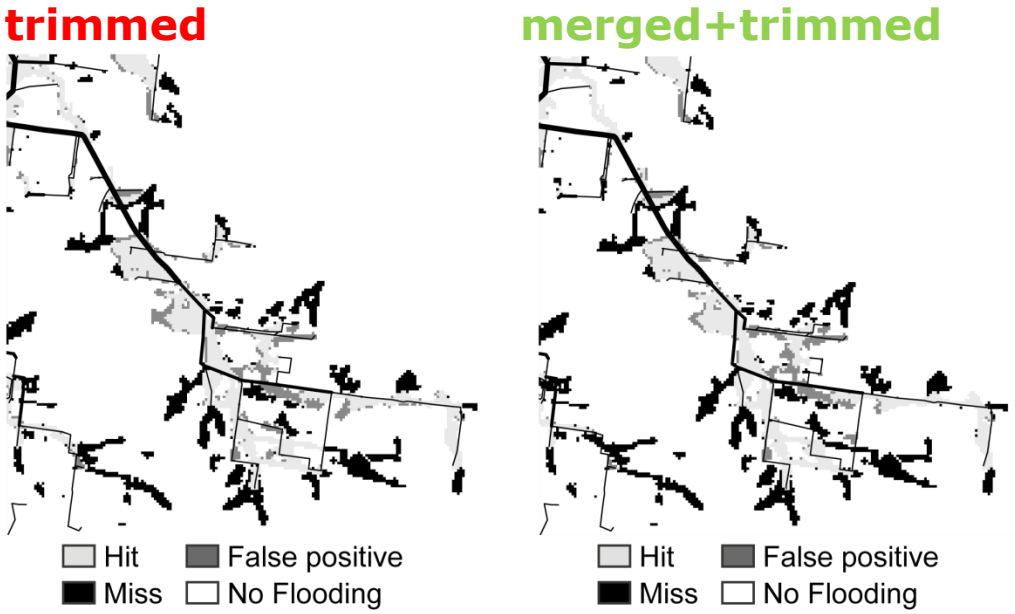
- fewer nodes → higher water levels in the system → faster flow?
- smaller energy losses when removing manholes?

Results – Flow 1D→2D (2 year event)

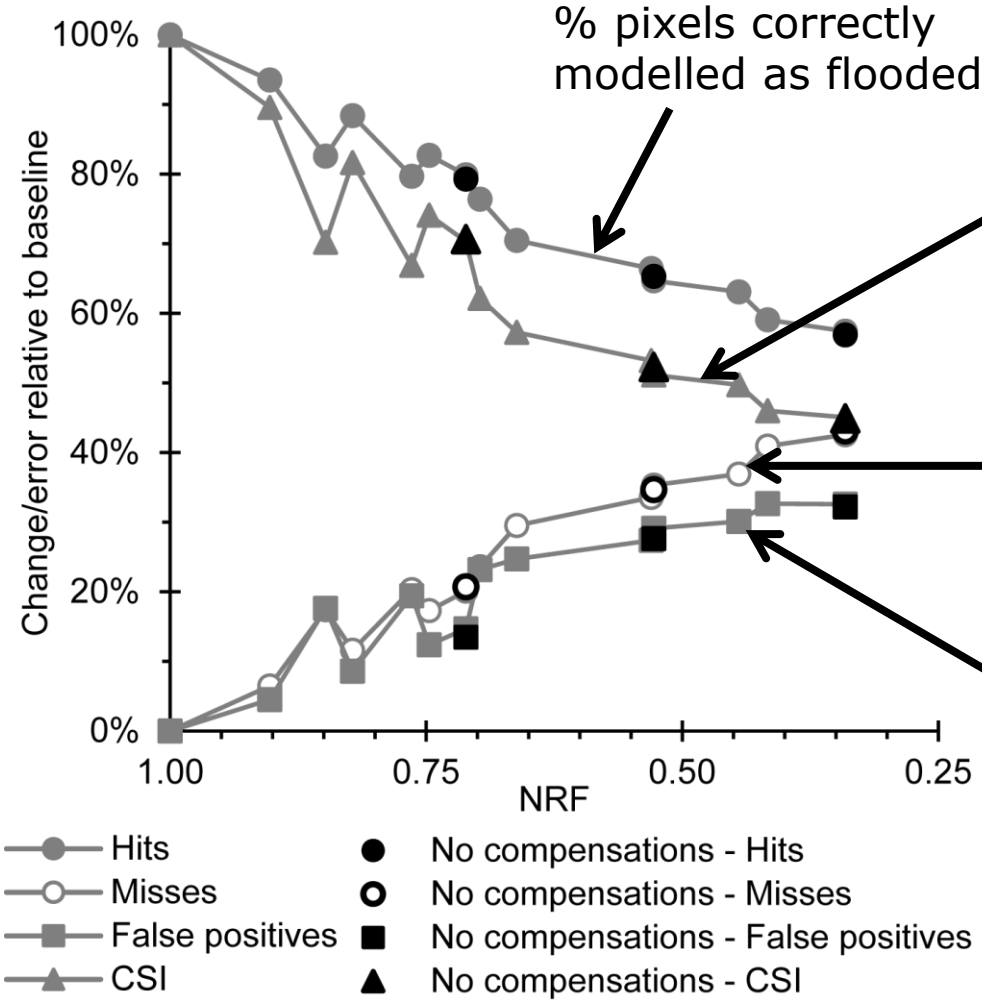


Results- Flooded Area





Results - Flooded Area



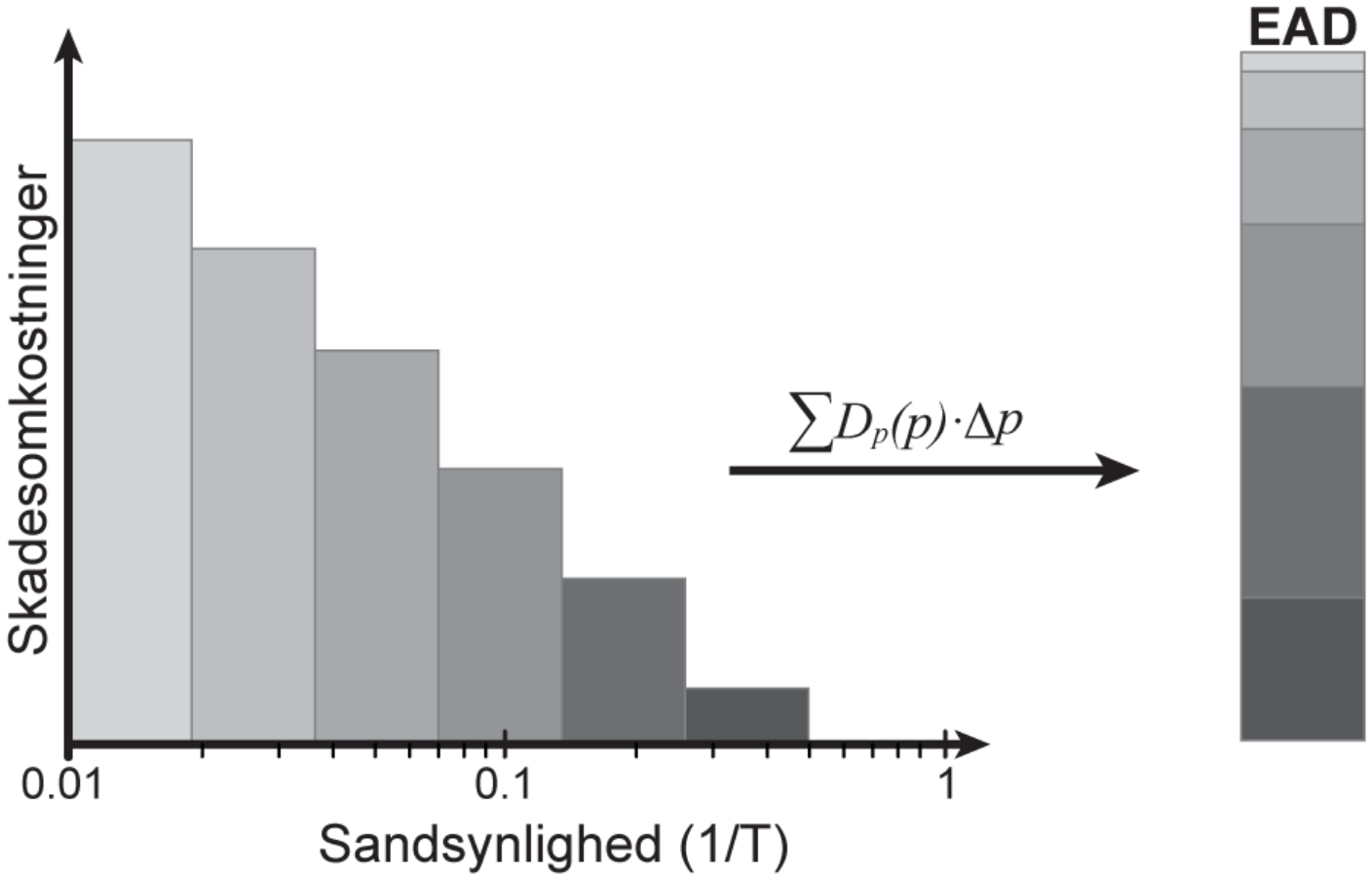
% pixels correctly modelled as flooded (Hits)

CSI skillscore

% pixels falsely not modelled as flooded (misses)

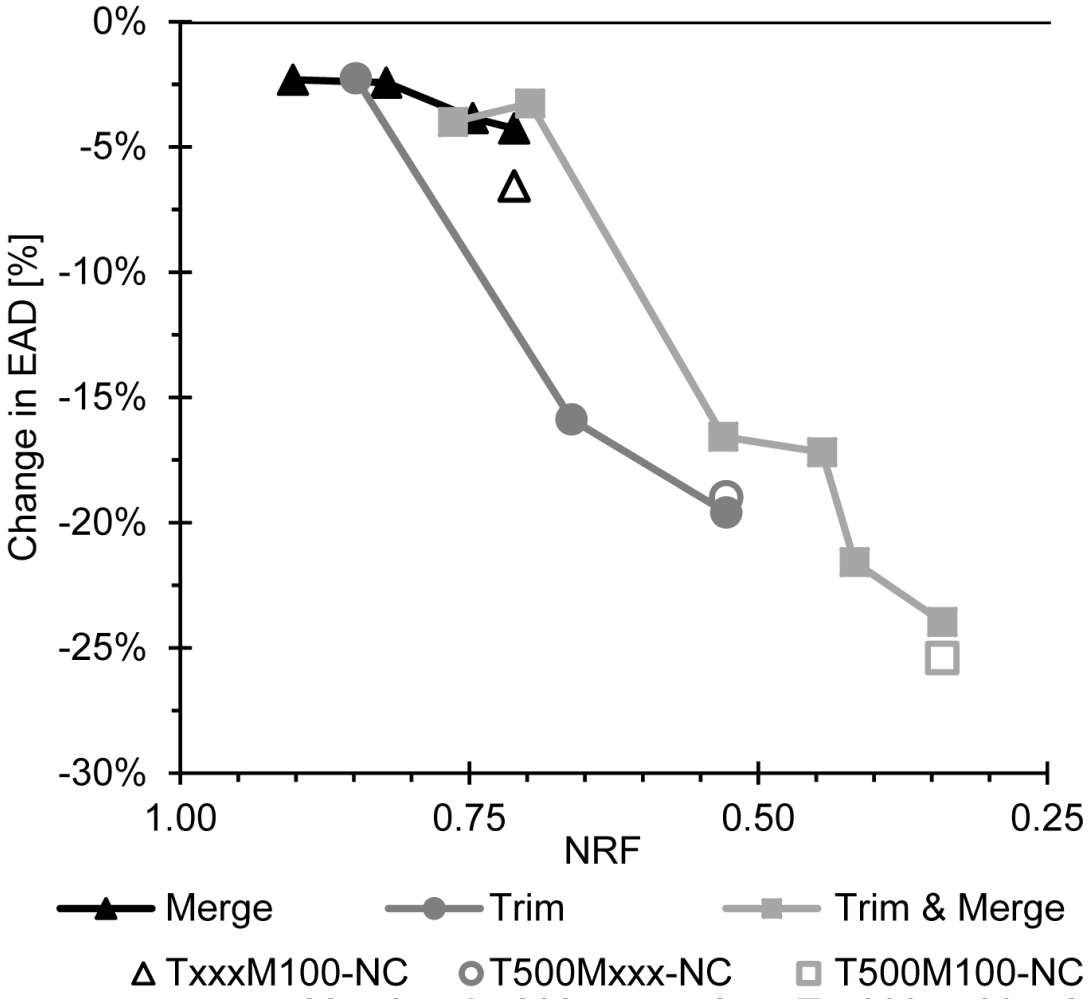
% pixels falsely modelled as flooded (false alarms)

Results - Expected Annual Damage (EAD)



from: SVK Skrift 31

Results - Expected Annual Damage (EAD)



Conclusions

1. 1D simplification had quite significant impact on simulation times (in a model with coarse surface resolution…)

2. Trimming affects flooded areas strongly

3. Somewhat higher peak flows when merging pipes

4. Little effect from travel time and volume compensations. Increased node diameter leads to large flows from 1D to 2D model.

https://gitlab.gbar.dtu.dk/users/rolo/projects

(tools for flood damage calculation, coupling 1D-2D models, parsing ERF files, 1D network simplification + clipping MU models

released under GNU GPLv3)

Davidsen, S., Löwe, R., Thrysøe, C., and Arnbjerg-Nielsen, K. (2017) Simplification of one-dimensional hydraulic networks by automated processes evaluated on 1D/2D deterministic flood models. Journal of Hydroinformatics, accepted.