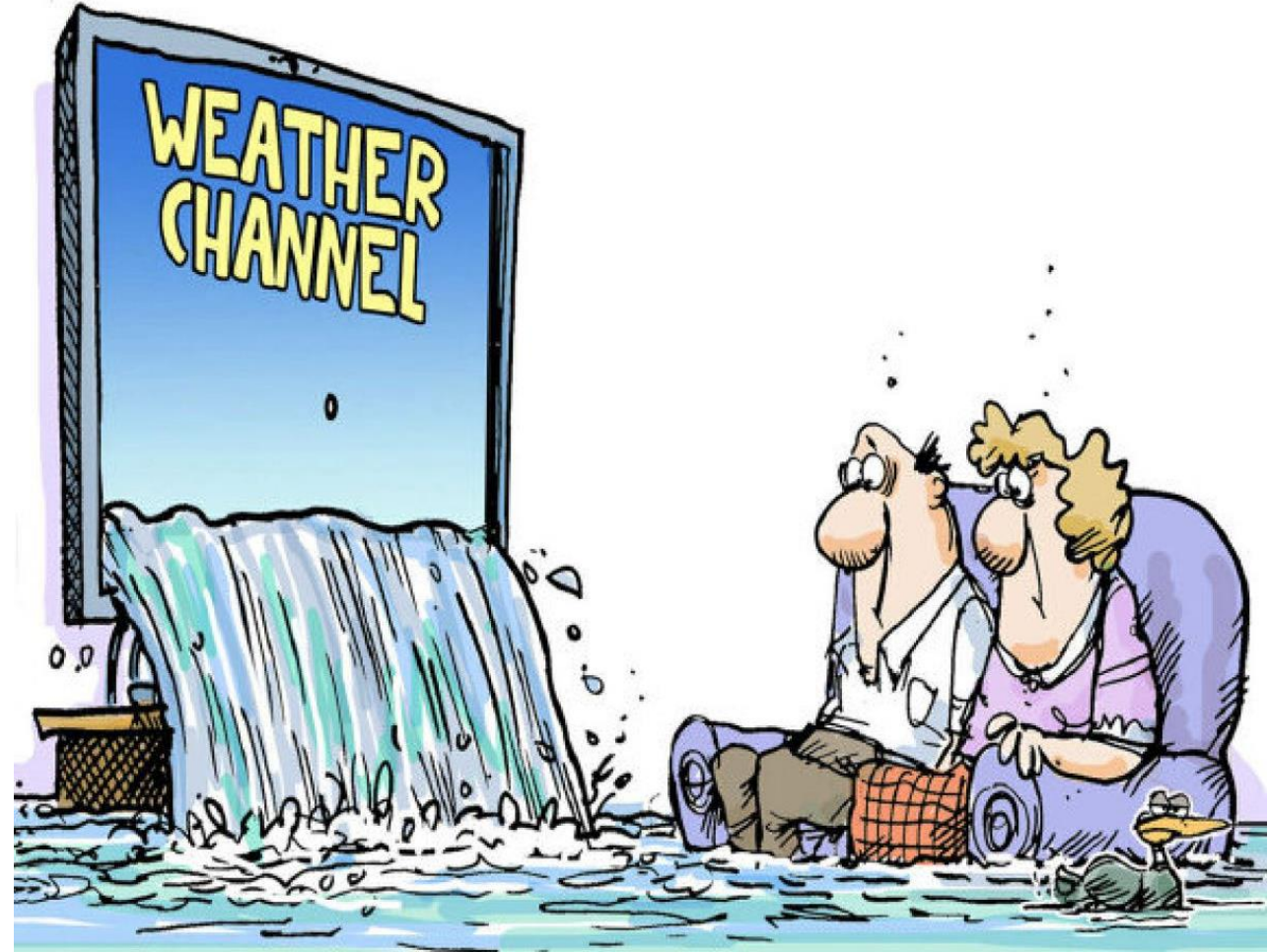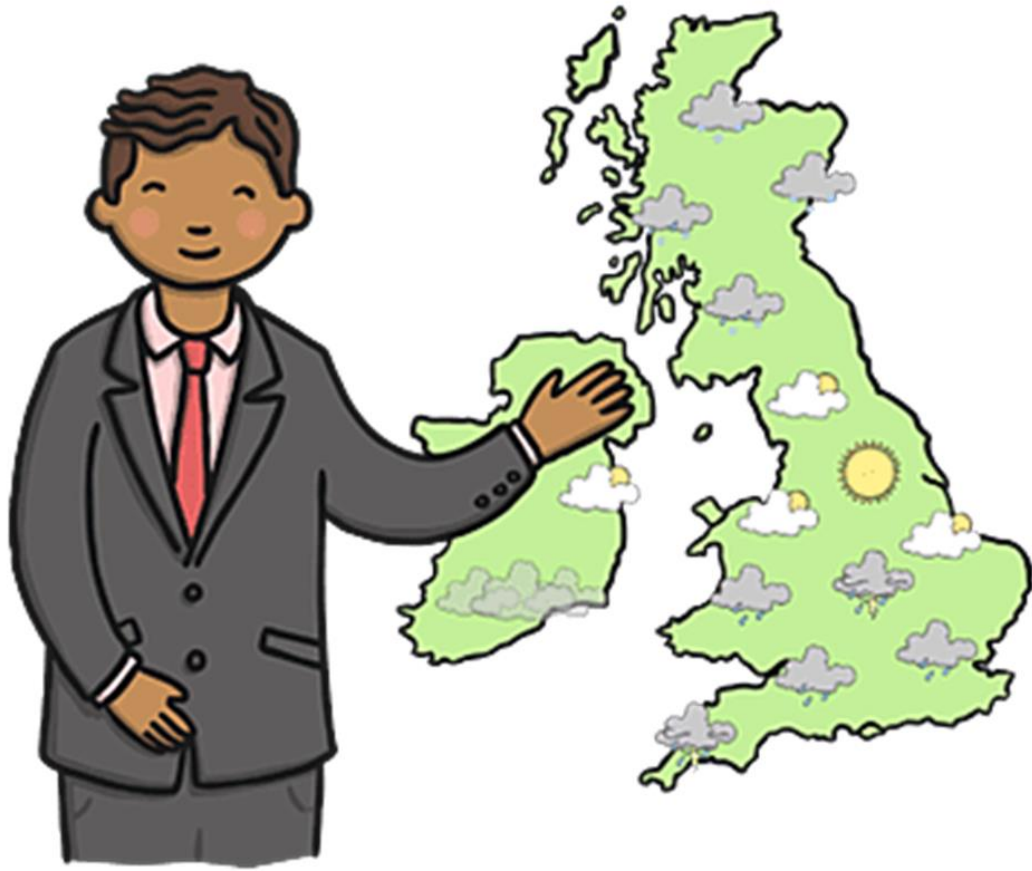# Efficient uncertainty quantification methods for flood modelling

Mahya Hajihassanpour (Researcher)

Georges Kesserwani (Supervisor)
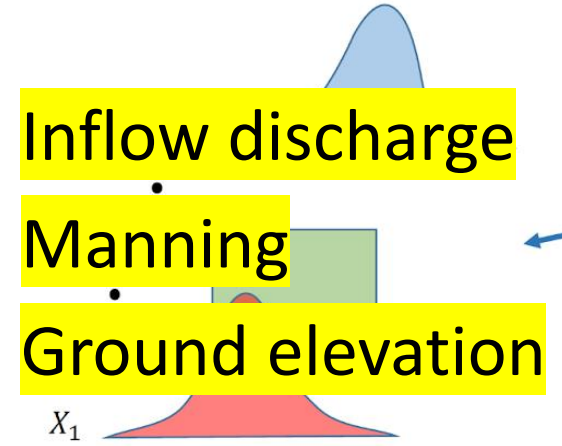
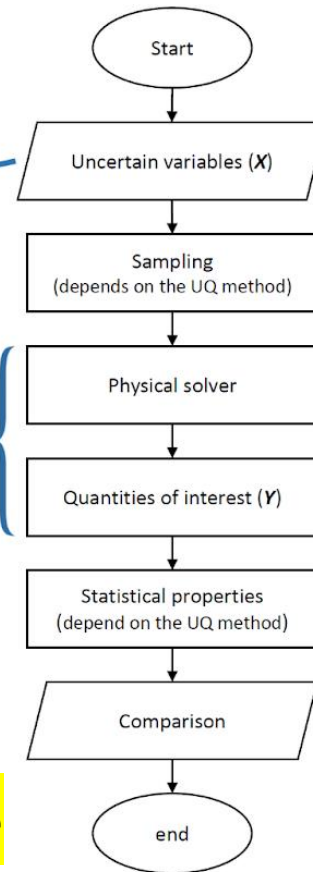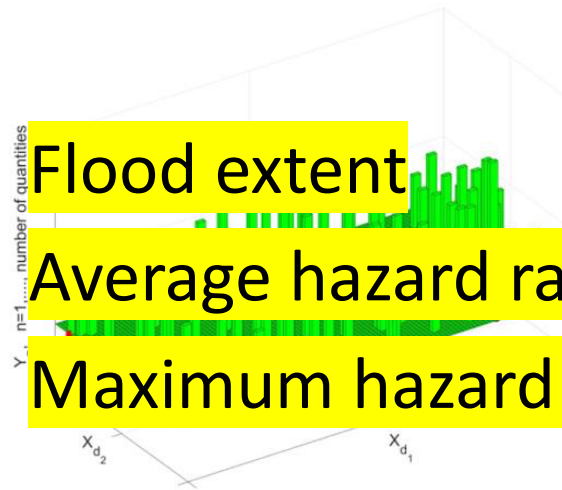Per Pettersson (Adviser)

Uncertainty Quantification (UQ)

UQ framework

- **Inflow discharge**
- **Manning**
- **Ground elevation**

- **Flood extent**
- **Average hazard rate**
- **Maximum hazard rate**

Start

Uncertain variables (X)

Sampling
(depends on the UQ method)

Physical solver

Quantities of interest (Y)

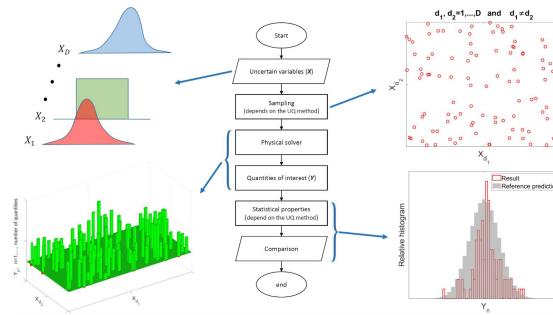Statistical properties
(depend on the UQ method)

Comparison

end

- **Standard Monte Carlo (SMC)**
- **Latin Hypercube Sampling (LHS)**
- **Adaptive Stratified Sampling (ASS)**
- **Quasi Monte Carlo (QMC)**
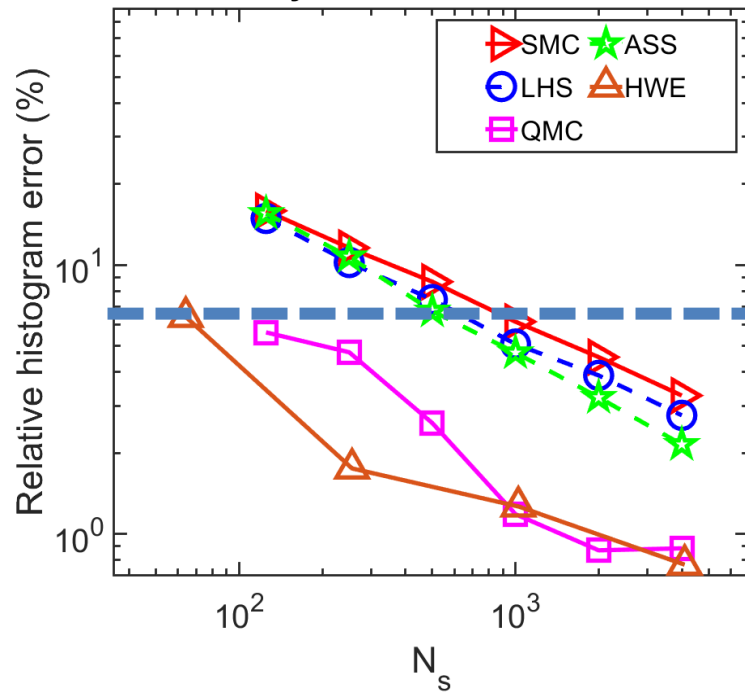- **Haar Wavelet Expansion (HWE)**
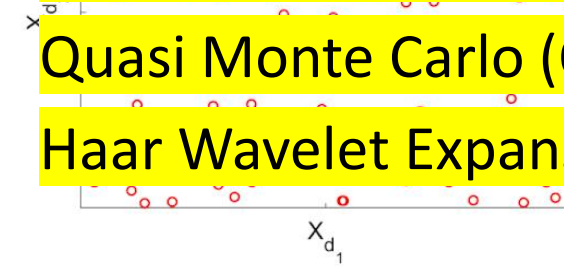
- **Mean**
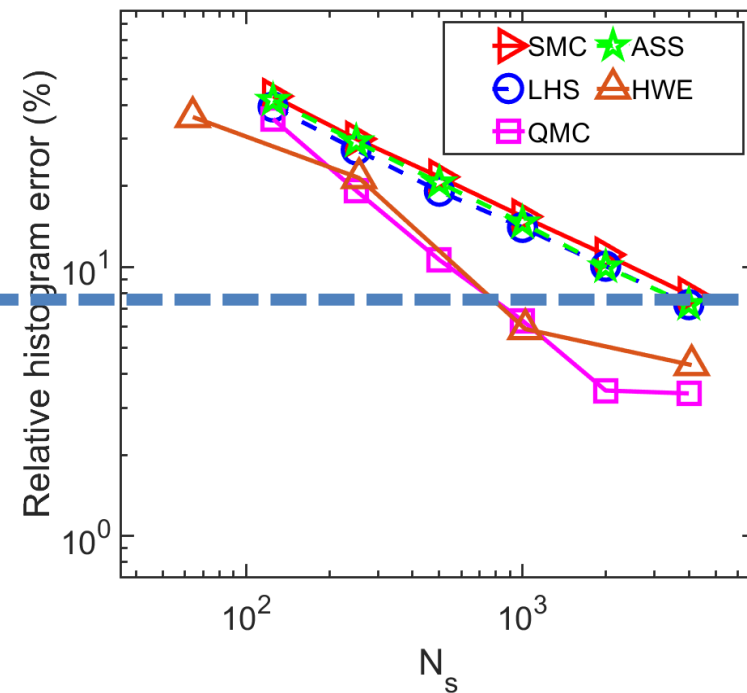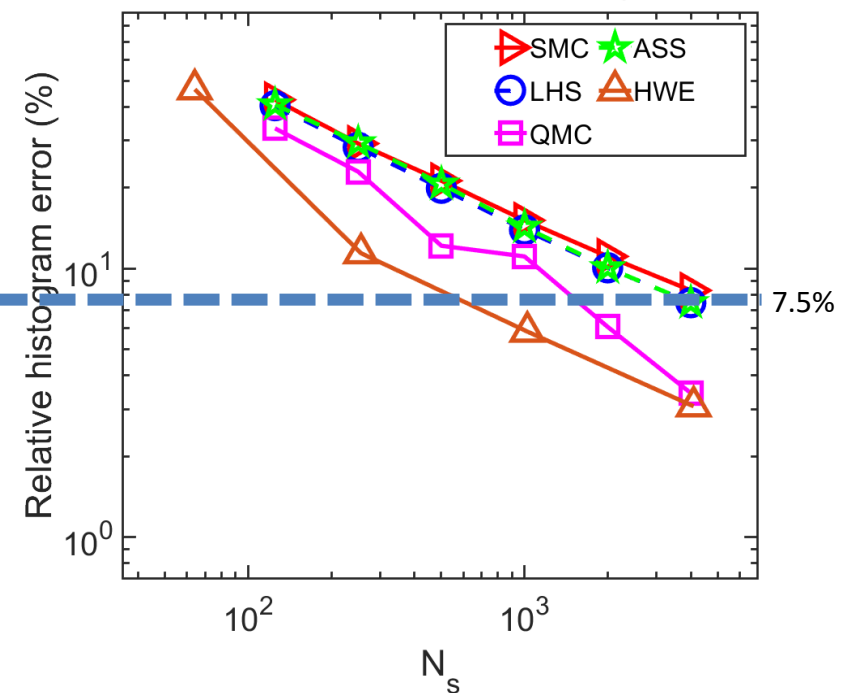- **Variance**
- **Histogram (main focus)**
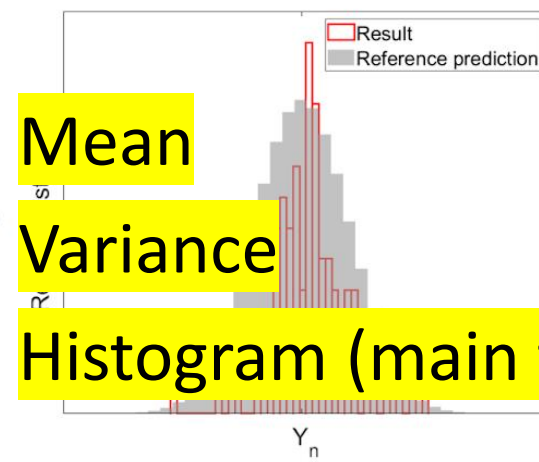
Comparison approach

Quantity of interest: Flood extent — Quantity of interest: HR_{ave} — Quantity of interest: HR_{max}

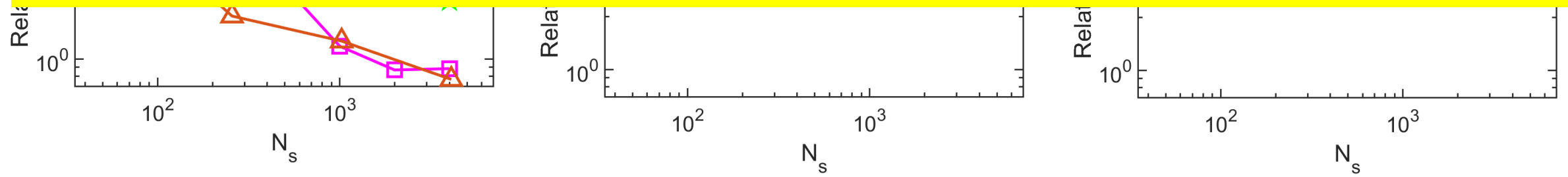SMC, ASS, LHS, HWE, QMC; Relative histogram error (%) vs N_s; 7.5%

Comparison approach
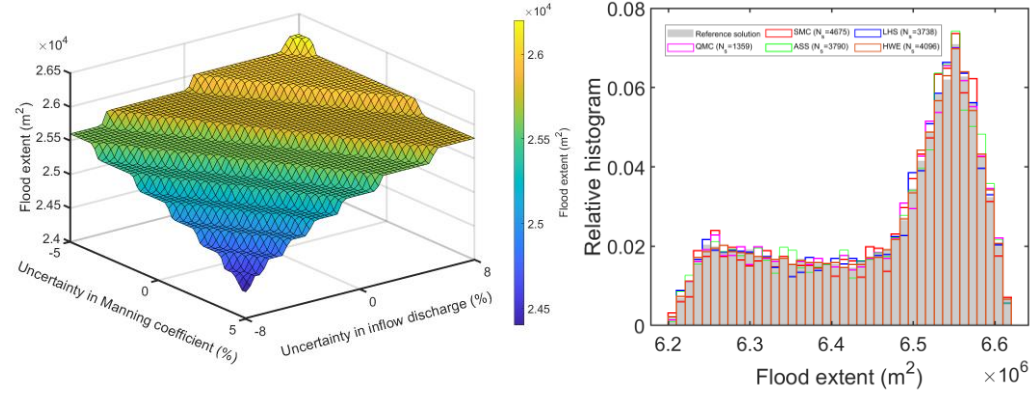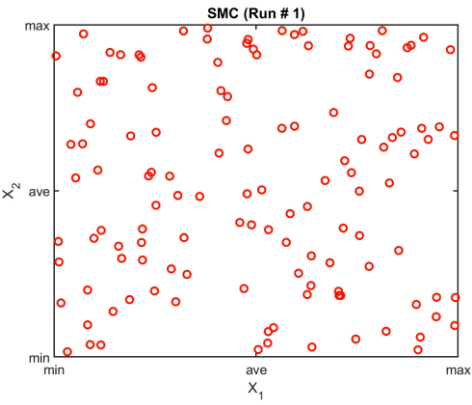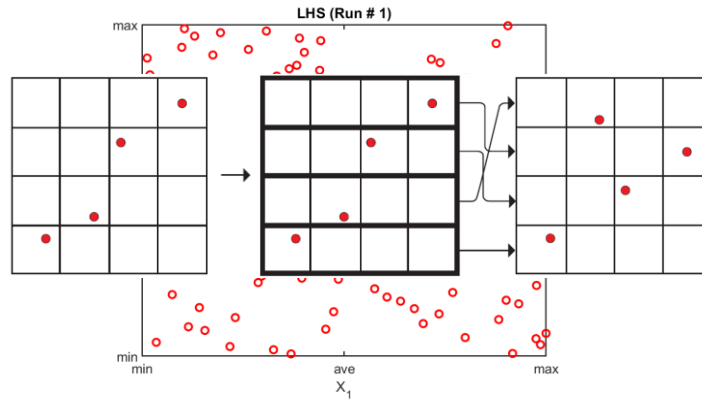

$$\text{Speedups:} \quad N_s^{SMC}/N_s^{method}$$
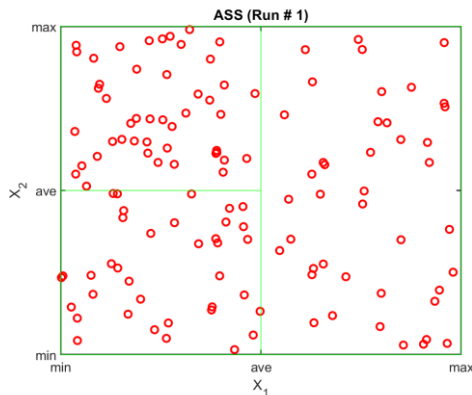
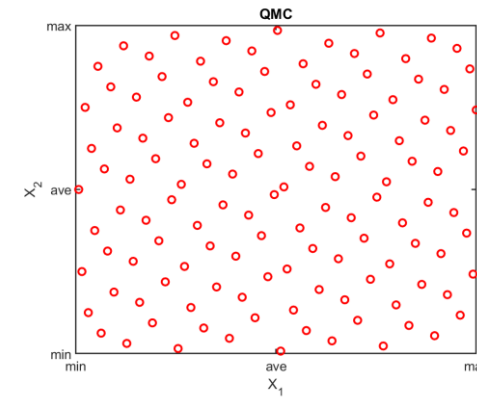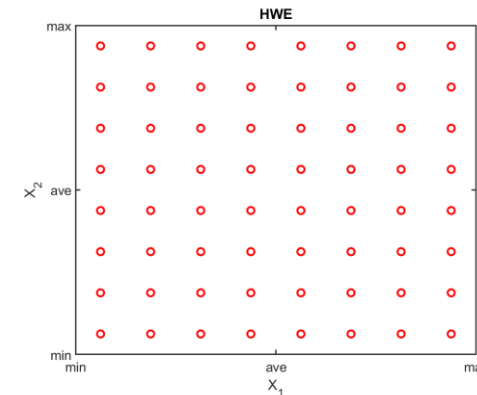# UQ methods

Random sampling methods
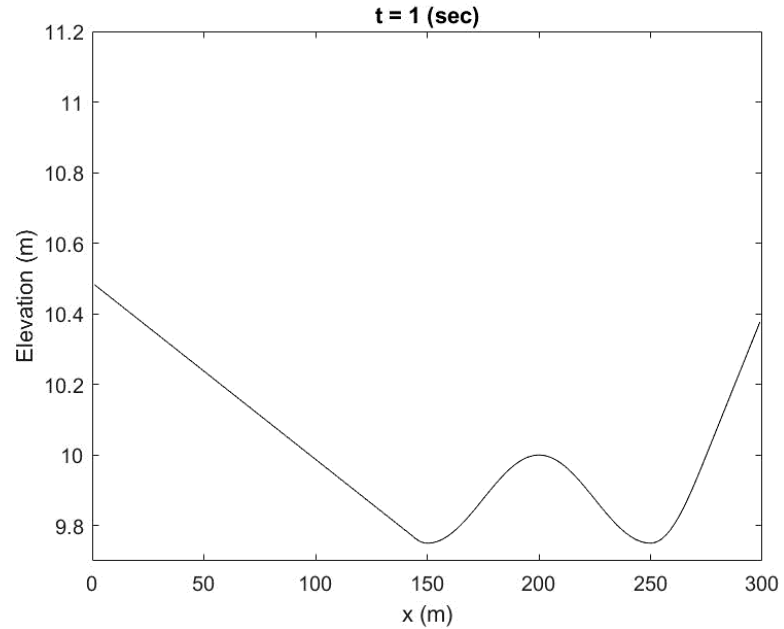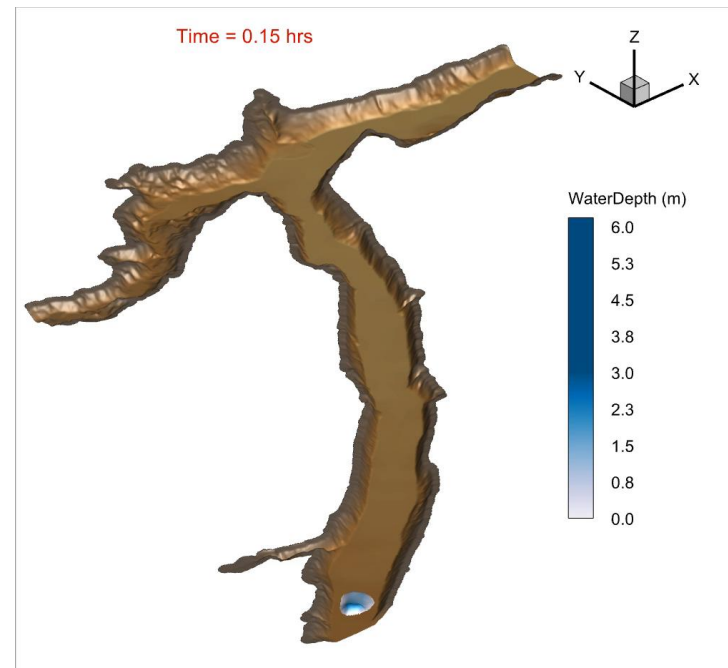
✓ SMS

✓ LHS

✓ ASS

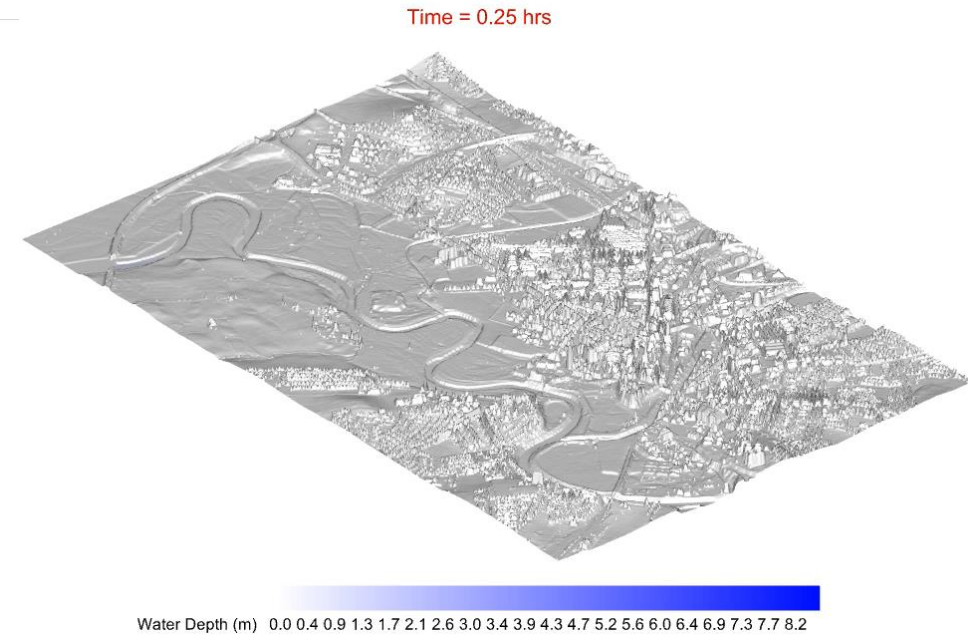**Deterministic realisation methods**

✓ QMC

✓ HWE

Benchmarking test cases
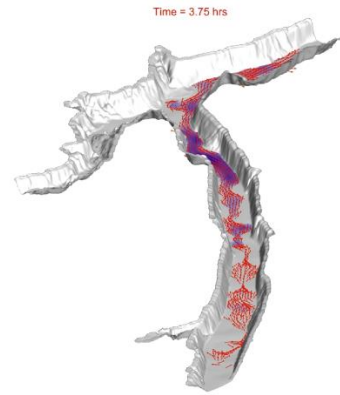
Rapidly propagating flood

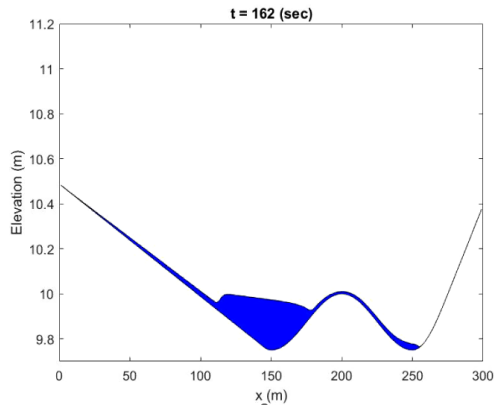### Flooding in a valley

Carlisle 2005 flood

Results

UQ method	Speedups (2D)		Speedups (3D)	
	min	max	min	max
ASS	1.2	1.4	0.98	1.01
	1.1	1.8	1.00	1.03
QMC	3	10	1.56	1.63
	1.1	25	0.52	2.13

Results

5D

Time = 40.75 hrs

QMC

Flood extent (m^2) $\times 10^6$

Flood extent (m^2) $\times 10^6$
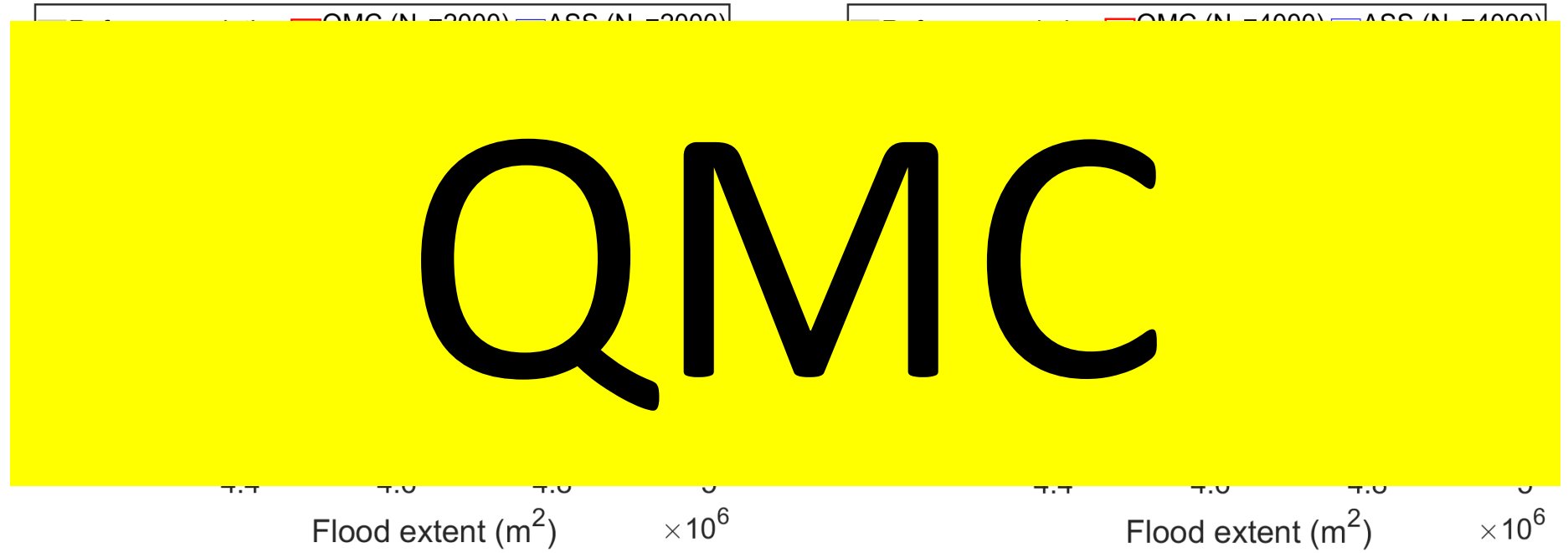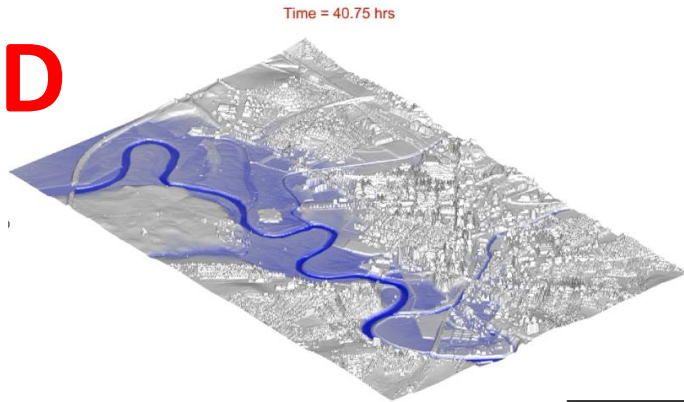
Conclusion

The performance of a UQ method depends on:

❖ Statistical properties:
- Mean (up to about 4300)
- Variance (up to about 3200)
- Histogram (up to about 25)

❖ Response surfaces: non-smoothness and nonlinearity, the lower performance

❖ The number of uncertain variables: the higher dimensions, the lower efficiency

❖ QMC is the best identified alternative candidate to SMC.

THANK YOU