Benchmarking Uncertainty Quantification methods in Flood Modelling

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SEAMLESS-WAVE

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UEA University of East Anglia · Loughborough University · University of Leeds · University of Bristol

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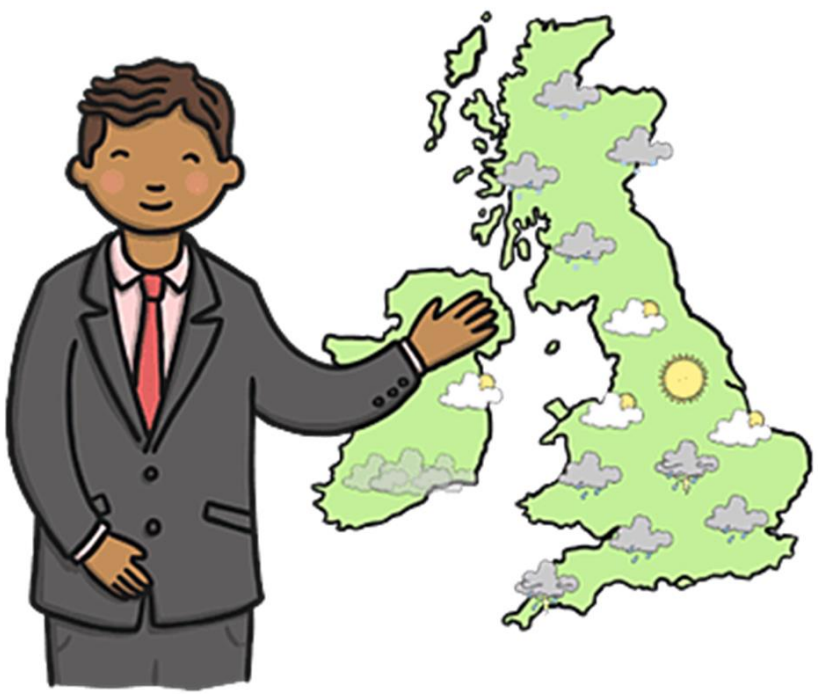
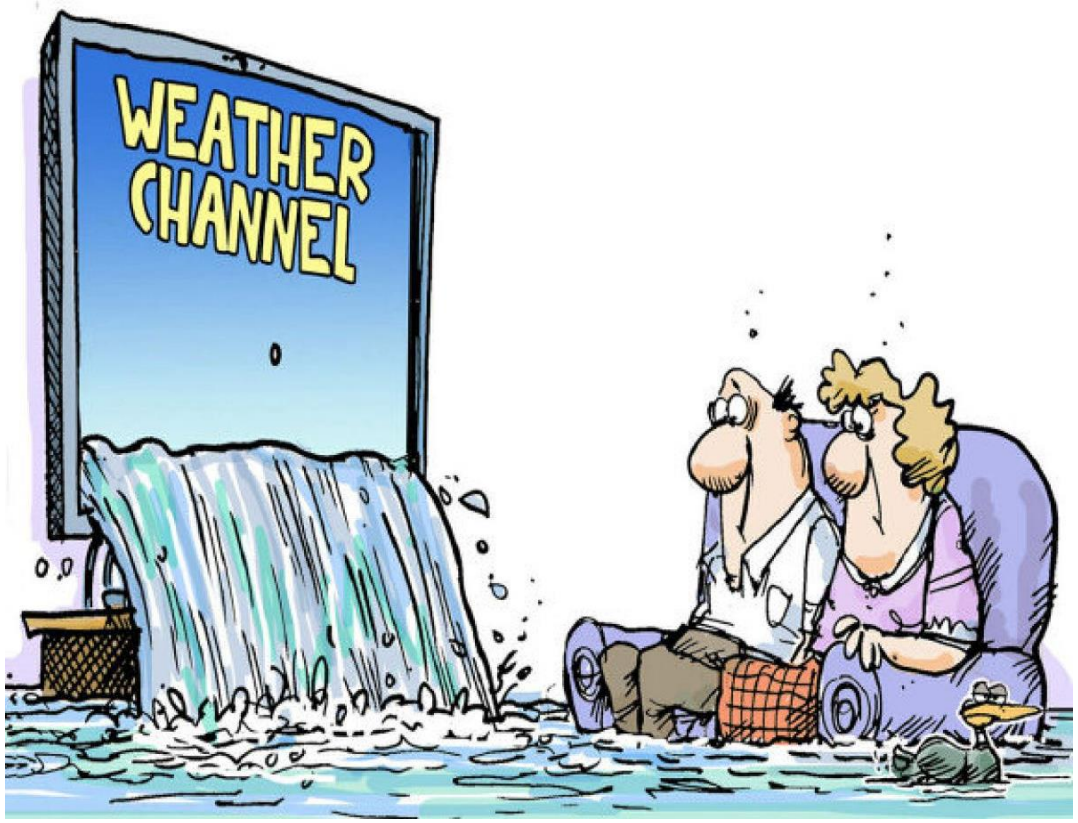
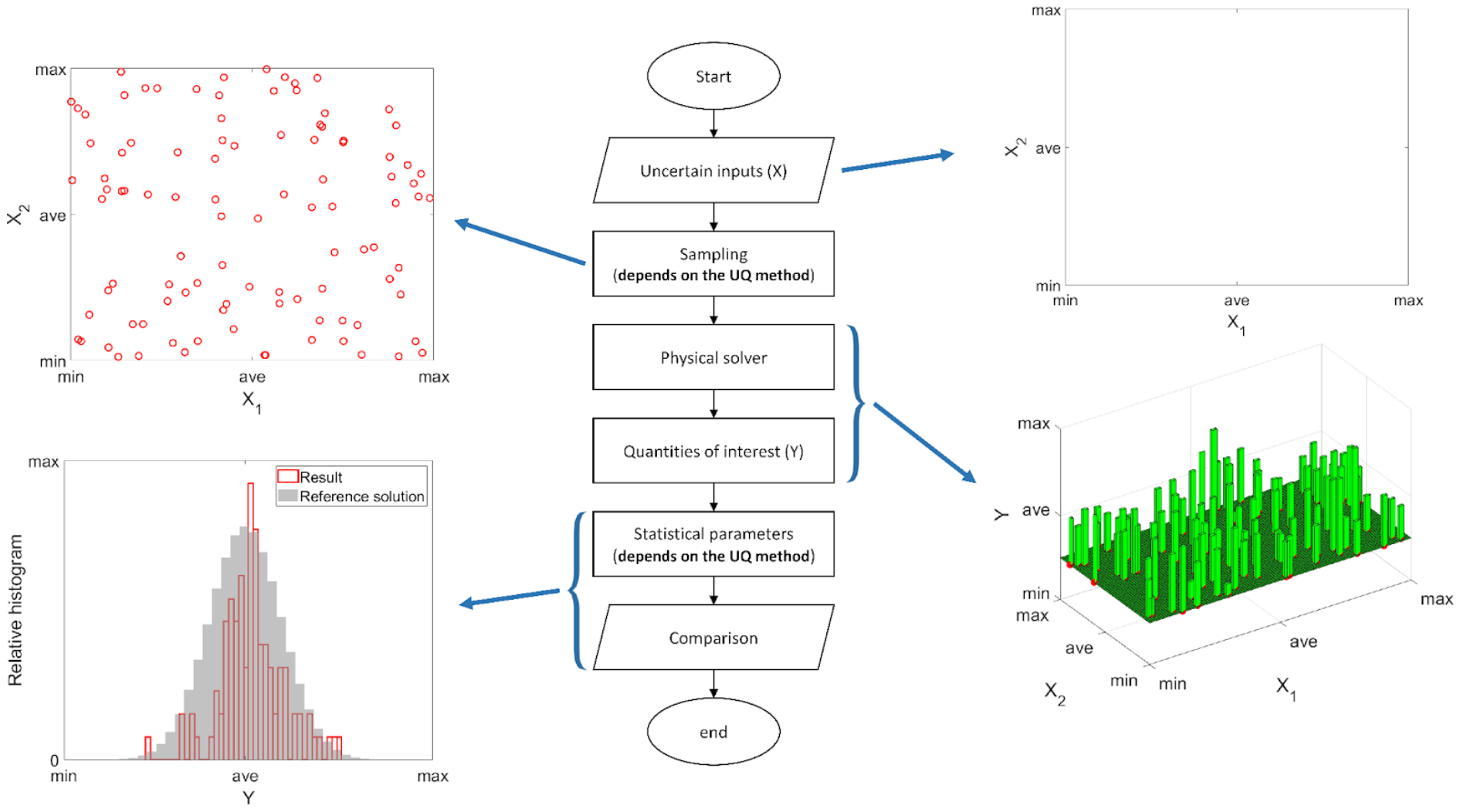
UNCERTAINTY QUANTIFICATION (UQ)





UQ ANALYSIS FRAMEWORK

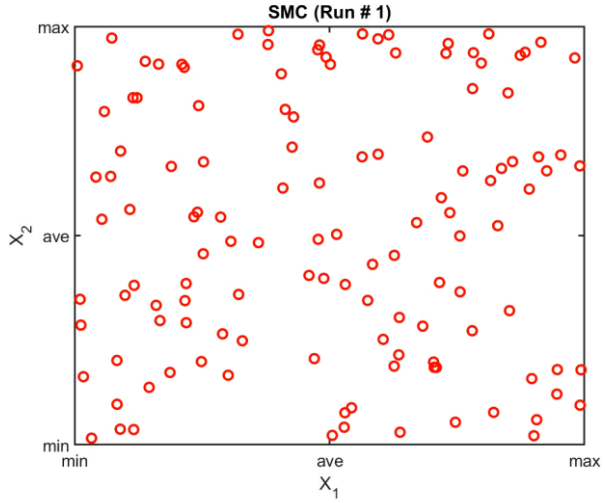


UQ METHODS

- **Traditional and widely used method**

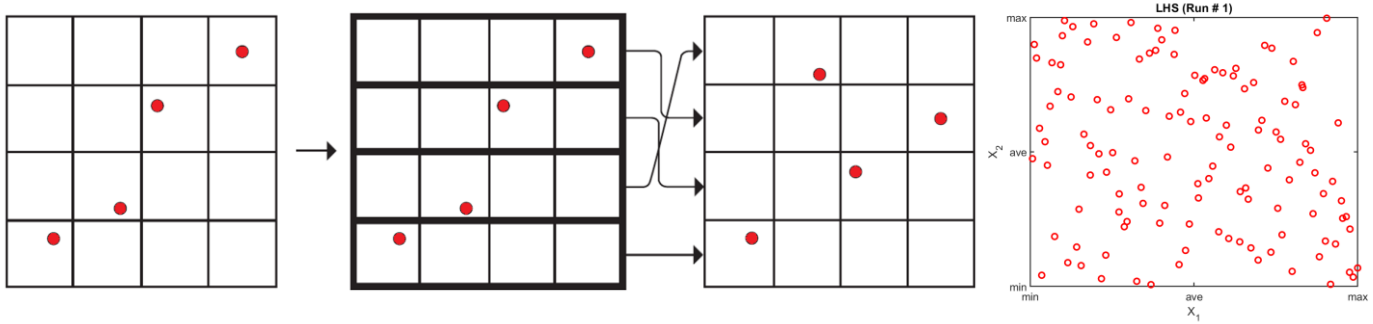
  Standard Monte Carlo (SMC)

  $\mathrm{RMSE} = \sigma / N_s^{1/2}$



- **Alternatives to the SMC method**

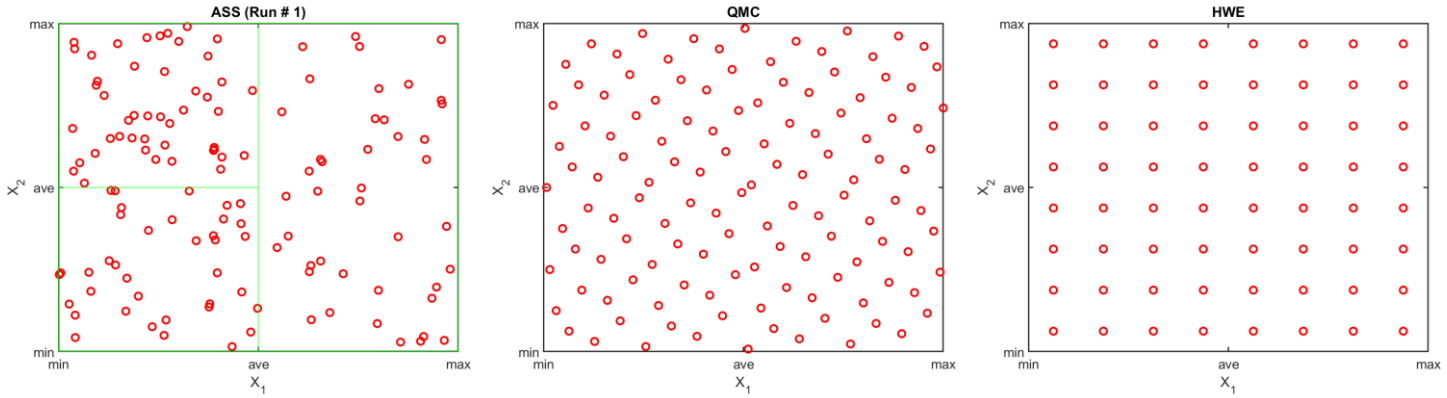
  ✓ Latin Hypercube Sampling (LHS)



  ✓ Adaptive Stratified sampling (ASS)

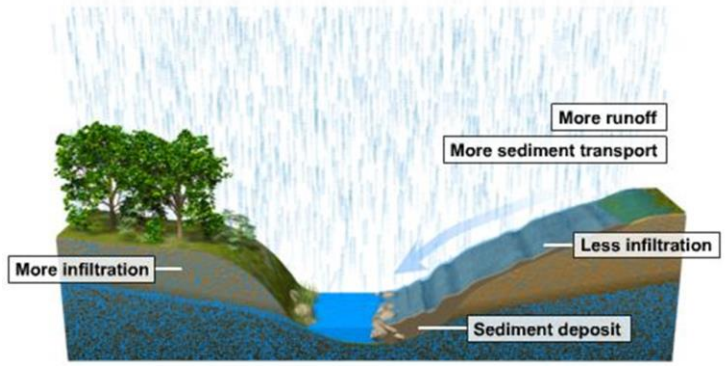
  ✓ Quasi Monte Carlo (QMC)

  ✓ Haar Wavelet expansion (HWE)



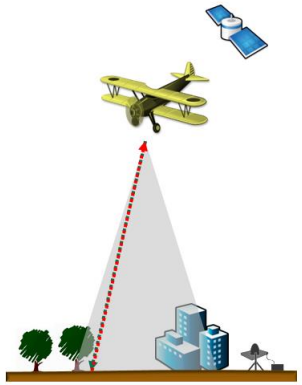
UNCERTAINTIES IN FLOOD MODELLING

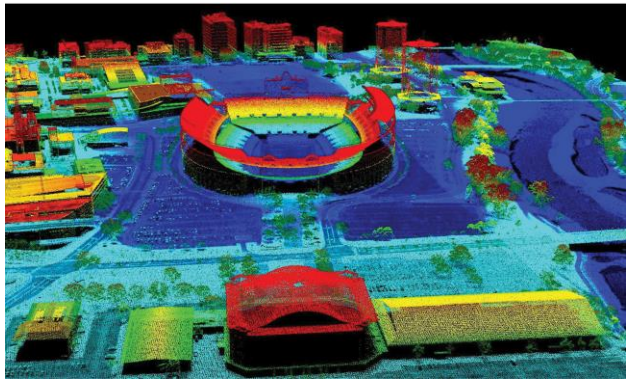
- Inflow discharge (~8%)



- Manning (~5%)

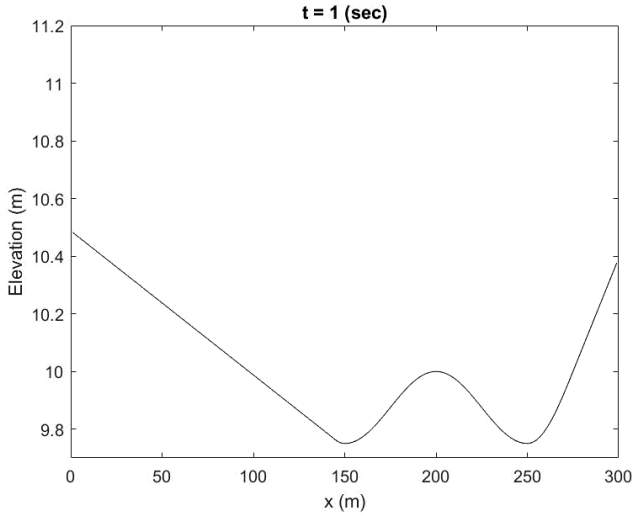
- Ground elevation ($|cML^2|$ and c~1)

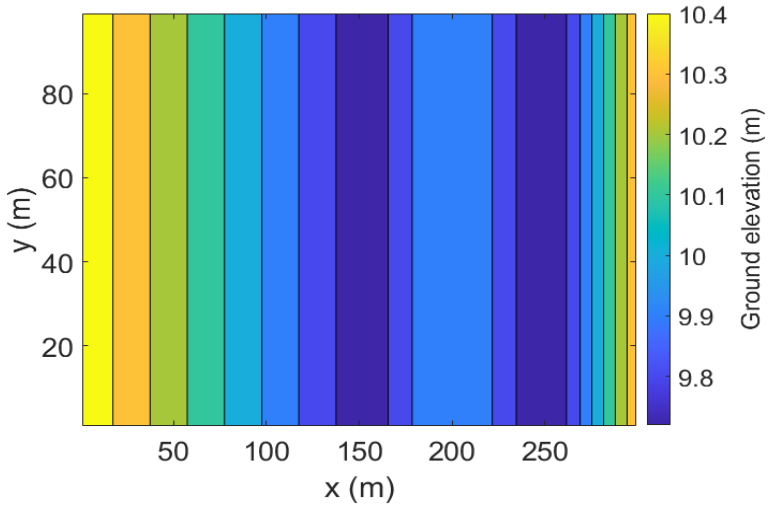


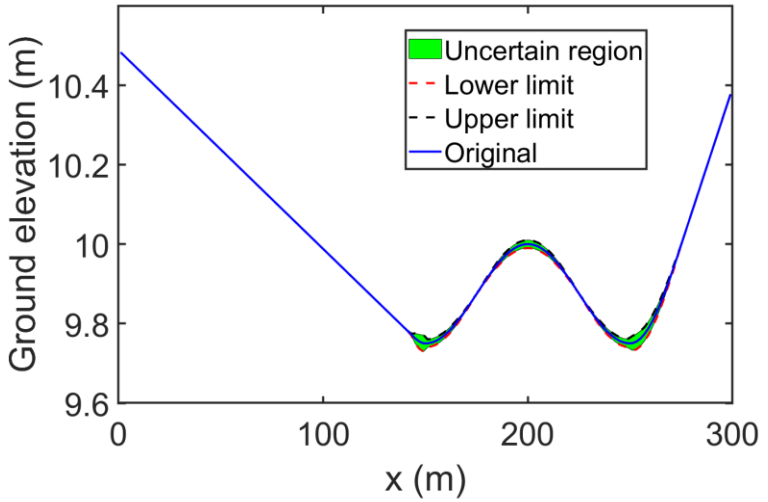


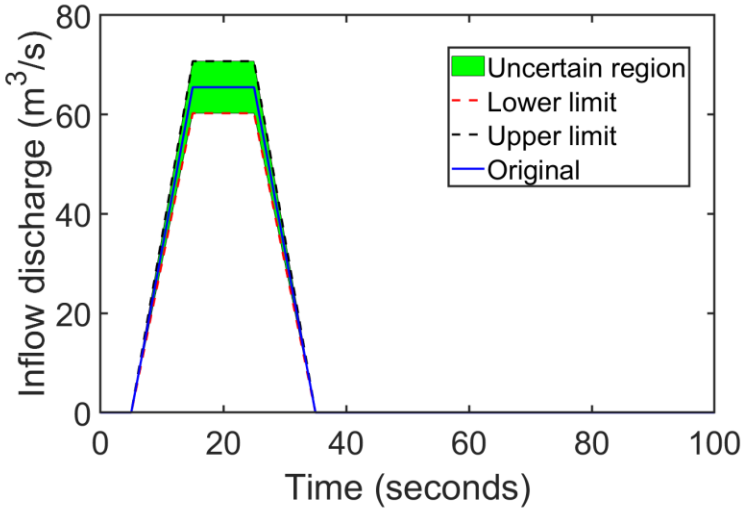
PROBLEM DEFINITION

- **Rapidly propagating flood (2D or 3D)**

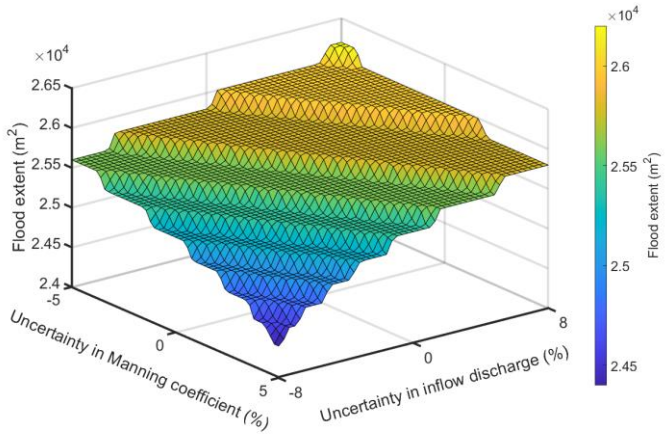


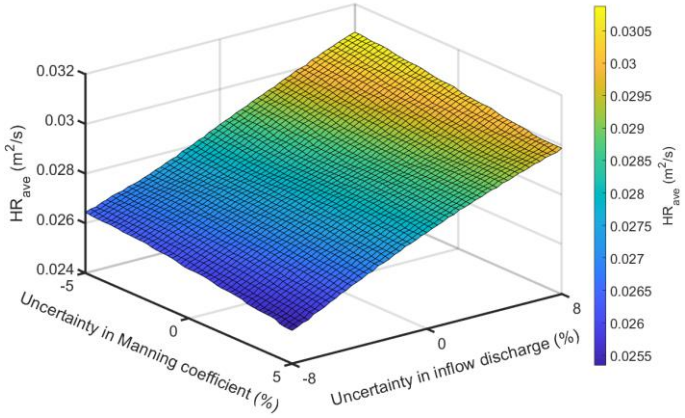


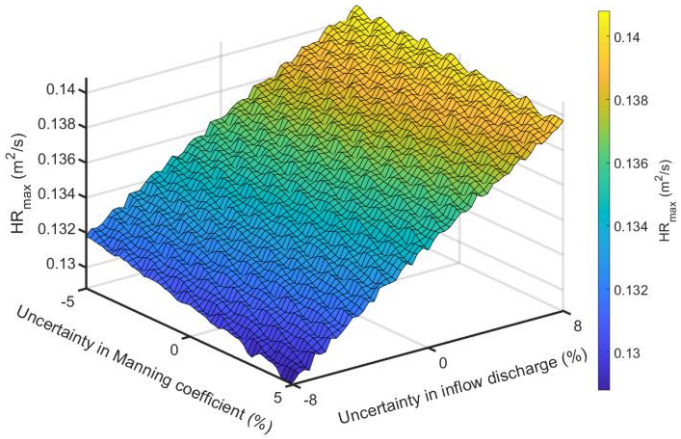


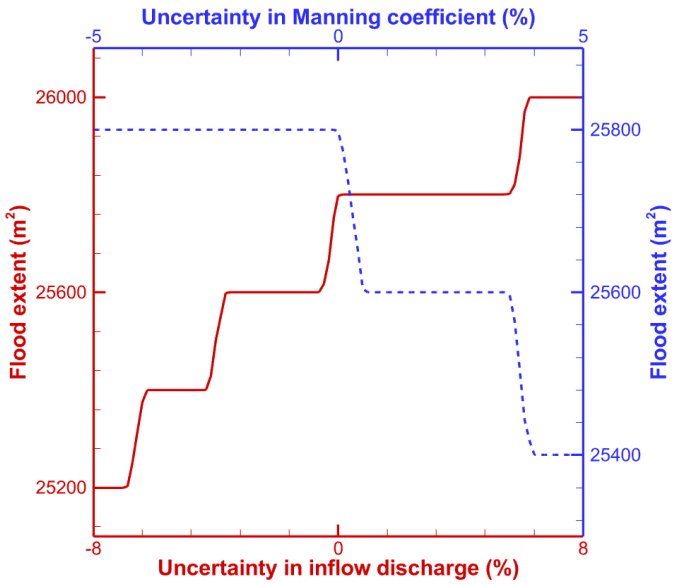


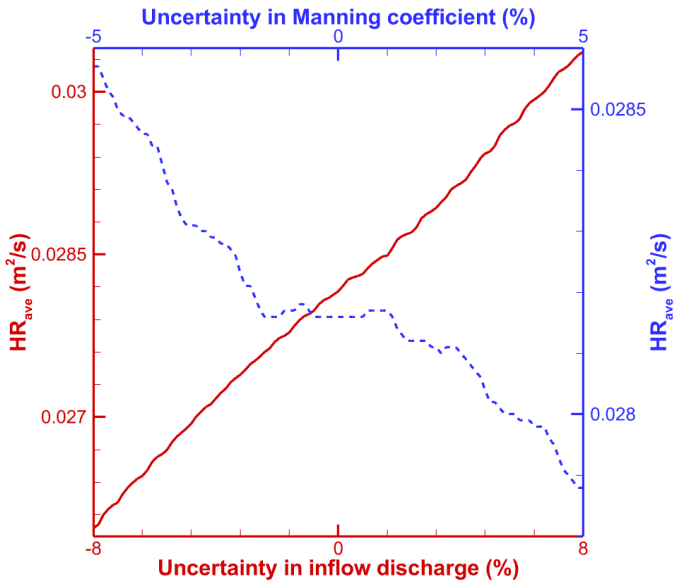
UNCERTAINTY PROPAGATION (2D)

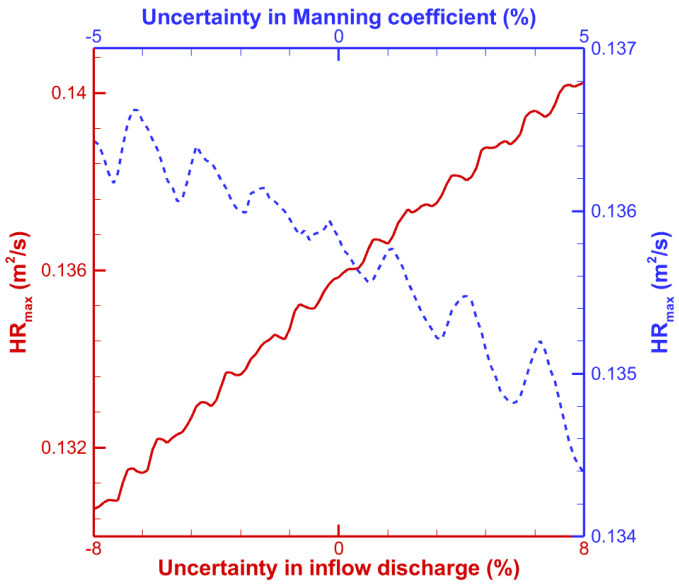




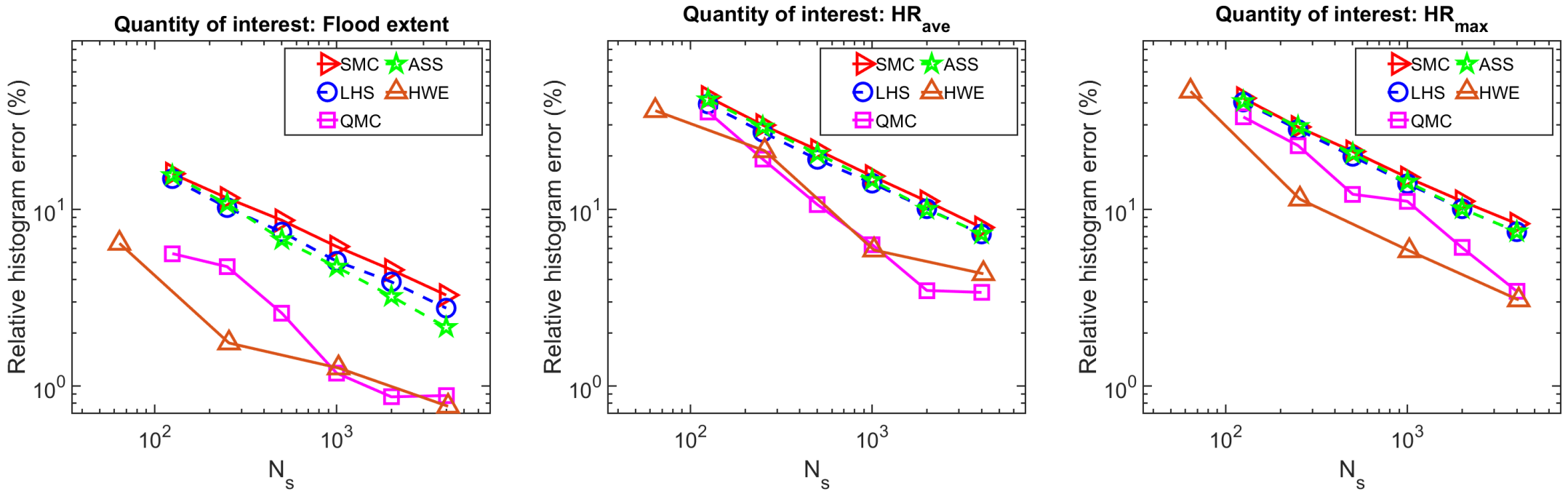








ERROR STUDY AND SPEEDUPS (2D)



- Average Speedups ($N_s^{SMC,92.5\%}/N_s^{method,92.5\%}$):

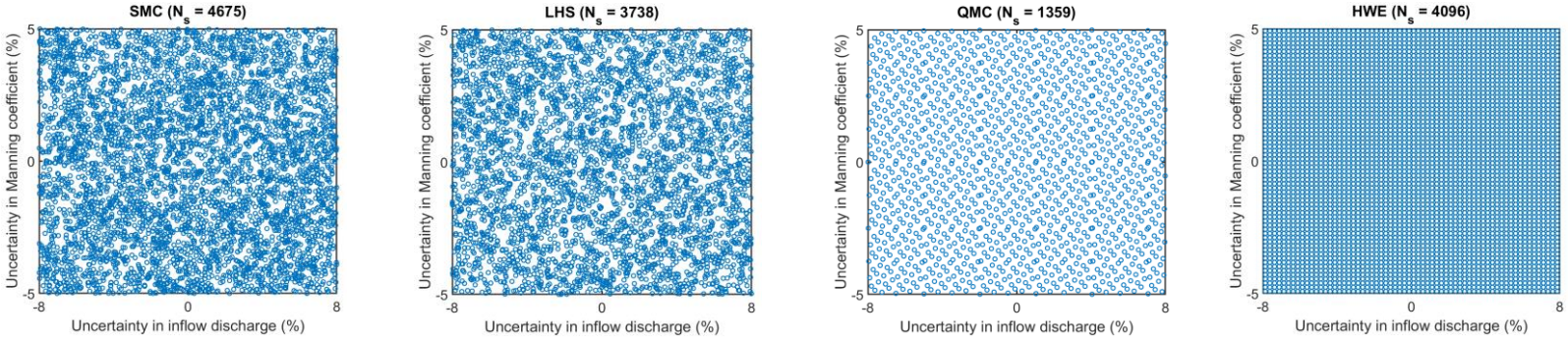
✓ LHS 1.27

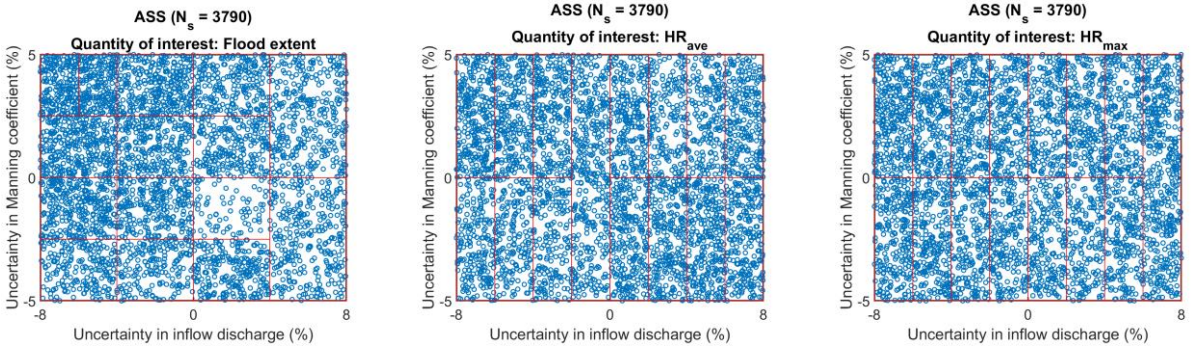
✓ ASS 1.30

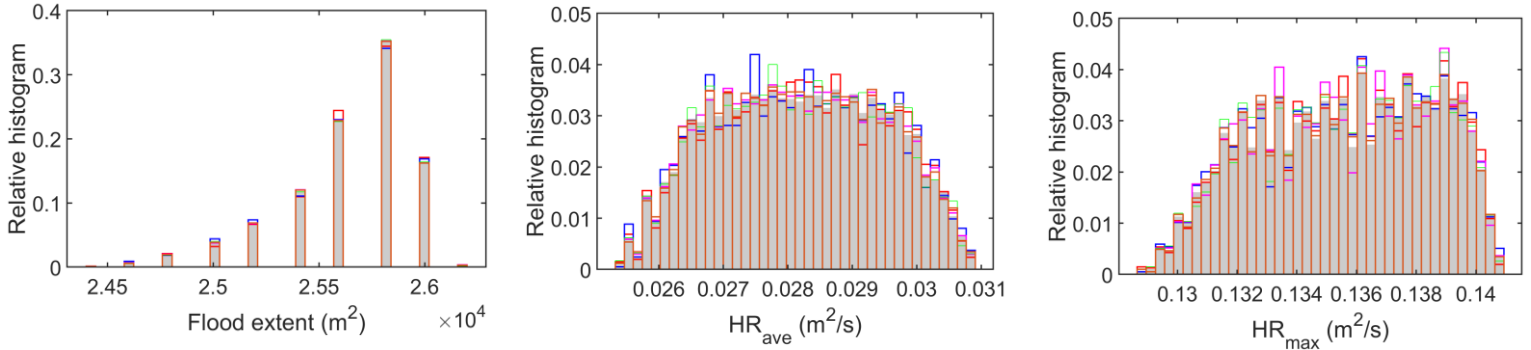
✓ QMC 5.57

✓ HWE 8.10

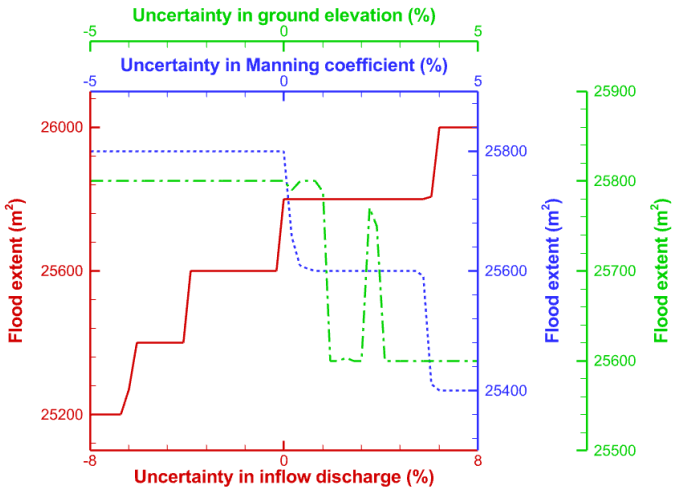
SAMPLES AND HISTOGRAMS (2D)

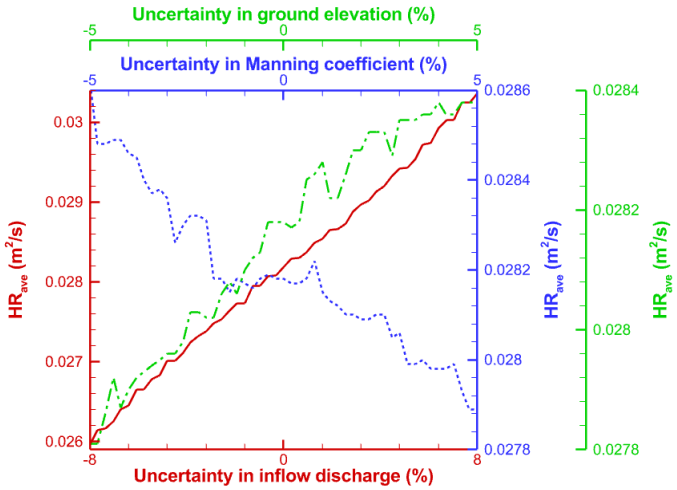


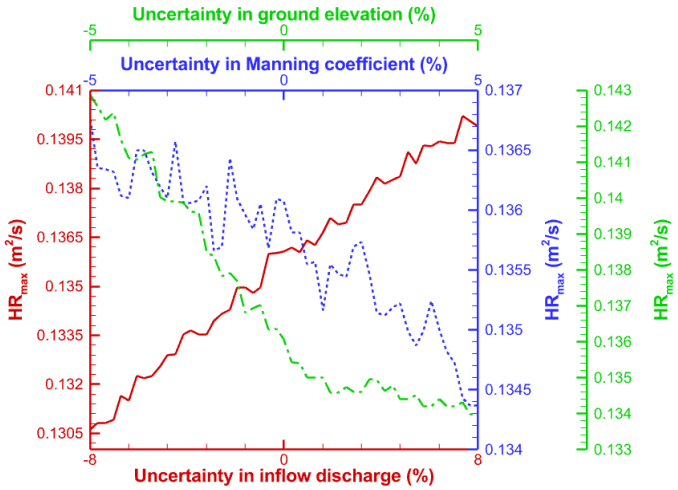




UNCERTAINTY PROPAGATION, ERROR STUDY AND SPEEDUPS (3D)

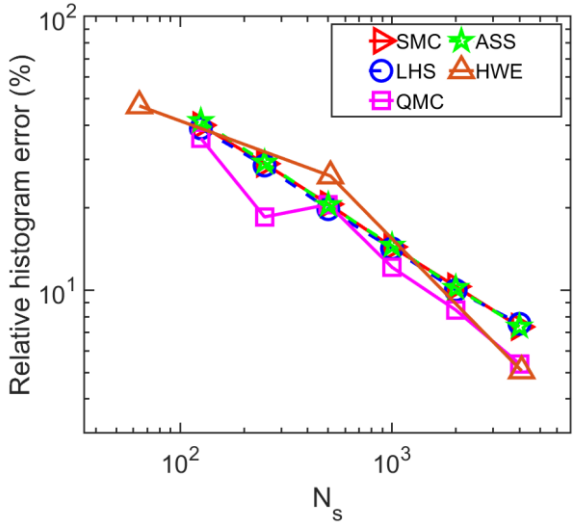






- Discrepancies between 3D and 2D cases:

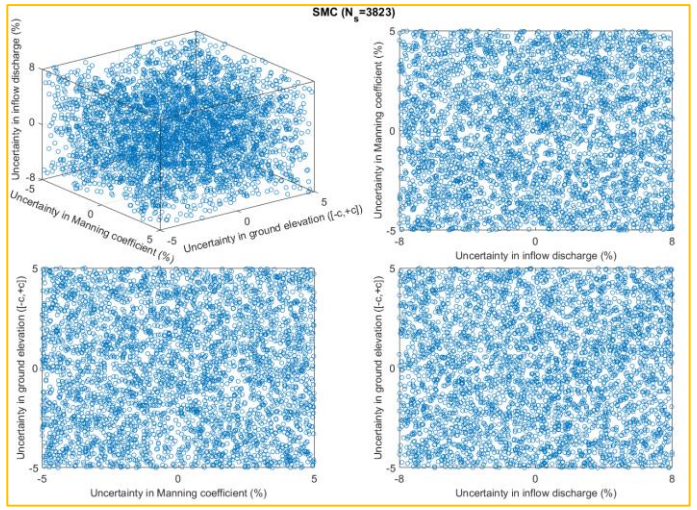
Flood extent	1.68%
HR_{ave}	7.35 %
HR_{max}	40.48 %

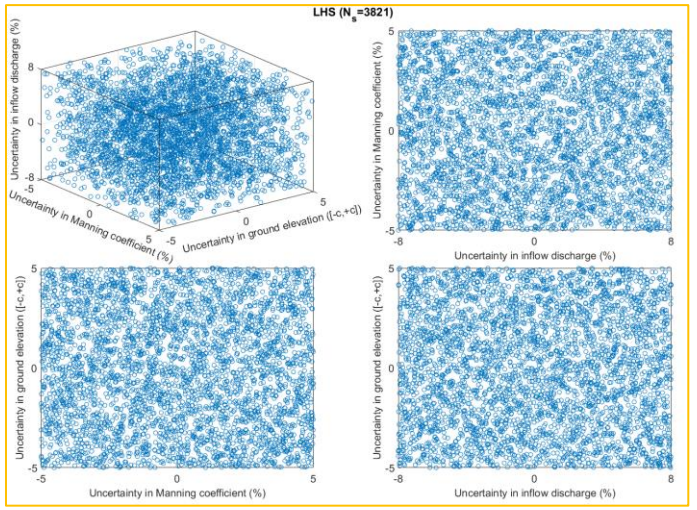


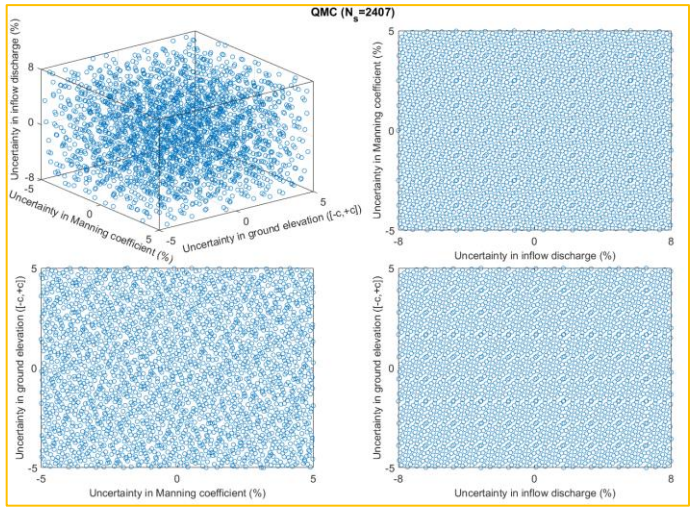
- Average Speedups:

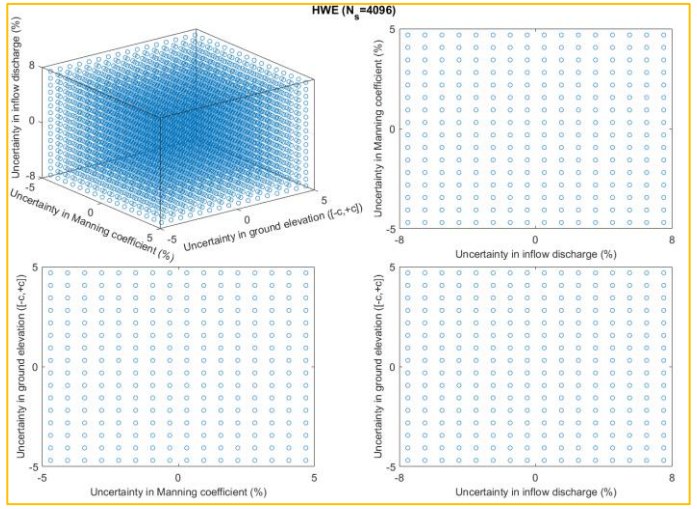
✓ LHS	1
✓ ASS	1.02
✓ QMC	1.59
✓ HWE	1.19

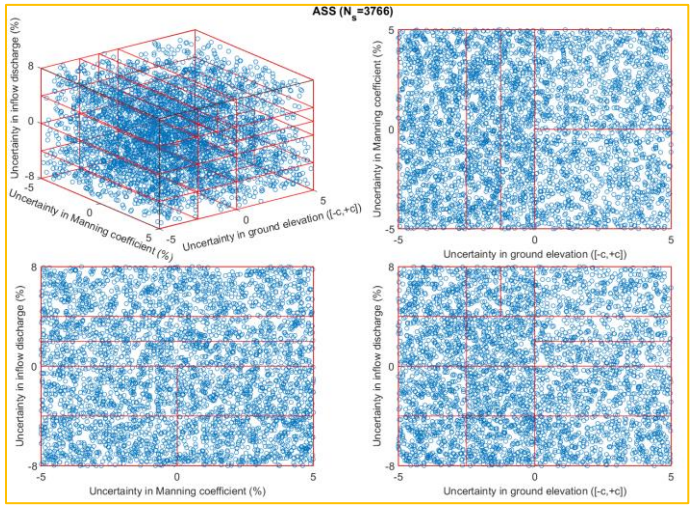
SAMPLES AND HISTOGRAMS (3D)

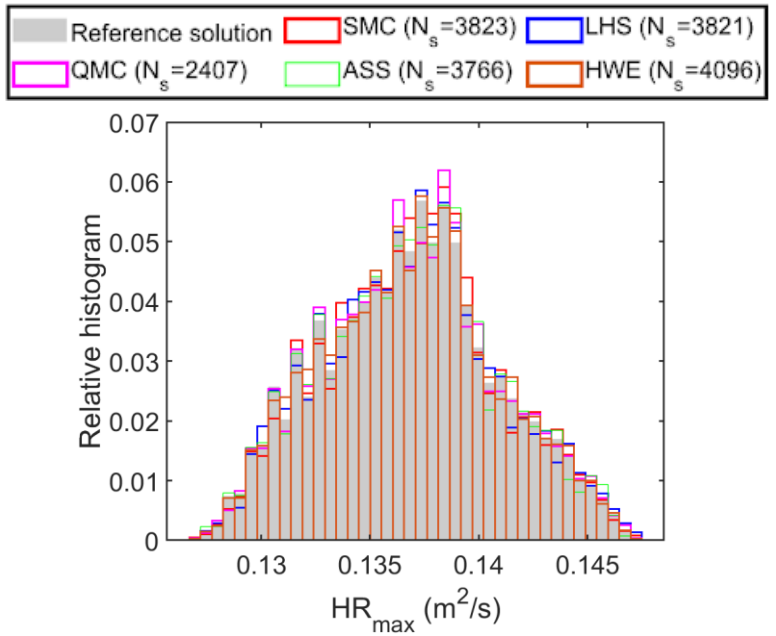












SUMMARY

- The LHS, ASS, QMC and HWE are appropriate alternatives to the SMC in terms of needing less number of samples to estimate a statistical parameter.

- Deterministic realisation methods (QMC and HWE) can be more efficient than the random sampling methods (SMC, LHS and ASS)

- The efficiency of the LHS, ASS, QMC and HWE reduces in 3D case in comparison with 2D case caused by the "curse of dimensionality" problem.

Thank you