Uncertainty Quantification in Gas Network Simulation

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- numerical simulation: uncertainties can arise in input data or model parameters
- uncertain parameters are modeled with random variables
- **forward propagation**: how do uncertainties in the input parameters affect the quantity of interest (QoI)?
  - specific outcome of solution
  - moments of solution (expectation, variance)
  - cdf of solution
- standard methods: stochastic Galerkin, stochastic collocation, (quasi-) Monte Carlo

[Sullivan, 2015]
■ scenario analyses are necessary to operate gas network safely and reliably
■ scenarios are not really tested but simulated
  ■ multiphysical network simulator MYNTS by HPA
■ uncertain input
  ■ how much gas does each customer withdraw?
■ forward propagation
  ■ what happens when all customers need a lot of gas at once?
  ■ can the network meet all demand peaks?
Methods

- stochastic Galerkin and stochastic collation methods
  - solution must be sufficiently smooth
  - fast convergence rates
- gas networks: kinks in the solution due to pressure regulation

- (quasi-) Monte Carlo methods
  - weak requirements on solution
  - poor convergence rates
Simplex Stochastic Collocation

- discretize parameter space with simplices
- piecewise polynomial approximation of solution
  - Lagrange interpolation through nearest neighbors
  - exact in sampling points  [Witteveen and Iaccarino, 2012a, 2012b, 2013]
- use the information whether a pressure regulator is active or not in the current simulation
  - separate approximation on each side of kink
  - at kink: minimum of both approximations
Results

- good pre-asymptotic behavior
- model error of $10^{-4}$ is reached with significantly fewer sampling points
  - speed up by factor $> 20$ compared to qMC

(a) $d = 2$
(b) $d = 3$
(c) $d = 4$


Thanks for your attention!