Probabilistic Risk Assessment of Groundwater Contamination Following Hydraulic Fracturing Operations

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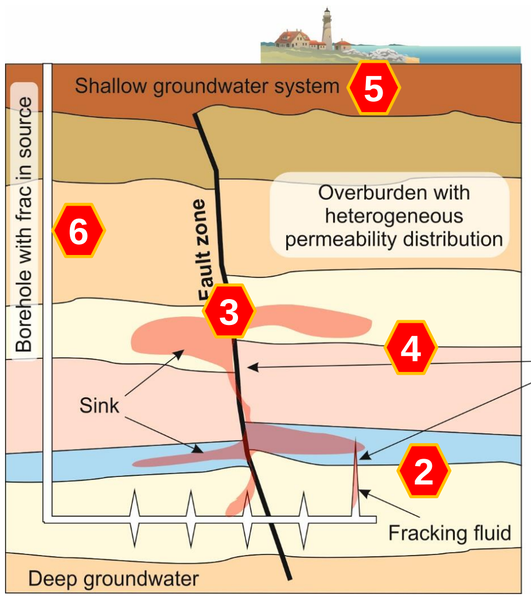
Methodology

- FracRisk is a research project funded by the European Union aiming at developing a decision support tool for the probabilistic assessment of environmental risks and impacts of hydraulic fracturing operations across shale gas reserves.
- Risk-Based Corrective Action (RBCA) methodology is implemented for risk analysis under uncertainty linked to Shale Gas operations.

Risk-based Approach - Source-Pathway-Receptor



1. Induced seismicity
2. **HC releasing overburden**
3. Migration along pathway
4. **Migration along overburden**
5. Propagation in aquifer
6. Diffusion overburden

Modeling

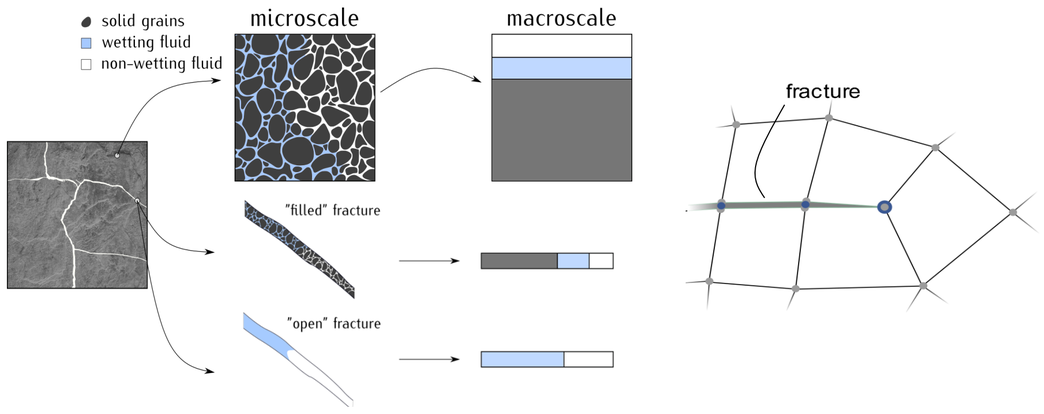
Shale Oil

Two-phase flow (no phase transfer)

$$\frac{\partial \phi \varrho_w S_w}{\partial t} - \nabla \cdot \left\{ \frac{k_{rw}}{\mu_w} \varrho_w \mathbf{K} (\nabla p_w - \varrho_w \mathbf{g}) \right\} - q_w = 0$$

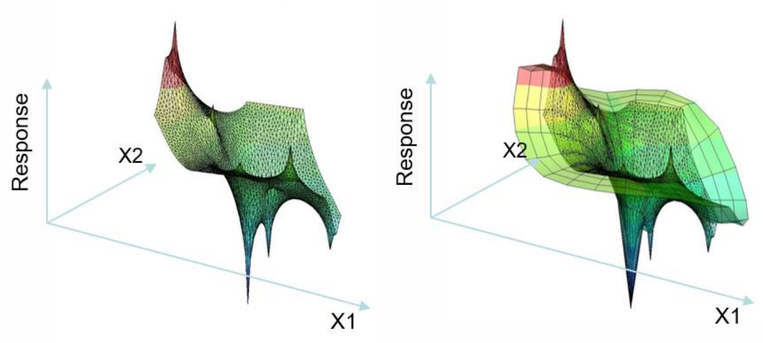
- Appraisal of an **oil-** and a gas- related scenario

Numerical Model



- Domain decomposition into a three-dimensional porous medium and lower-dimensional inclusions representing fractures or faults
- Fractures and faults are discretized by lower-dimensional elements which are conforming to faces of the discretization of the bulk domain
- Fractures act as boundaries for the bulk domain
- Mass transfer is modeled via a source term in the faults/fractures

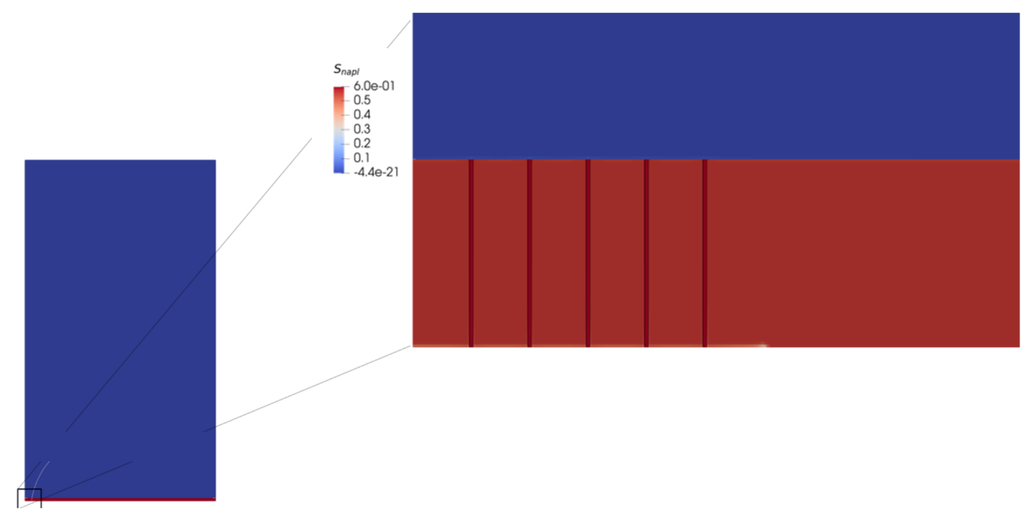
Surrogate Modeling

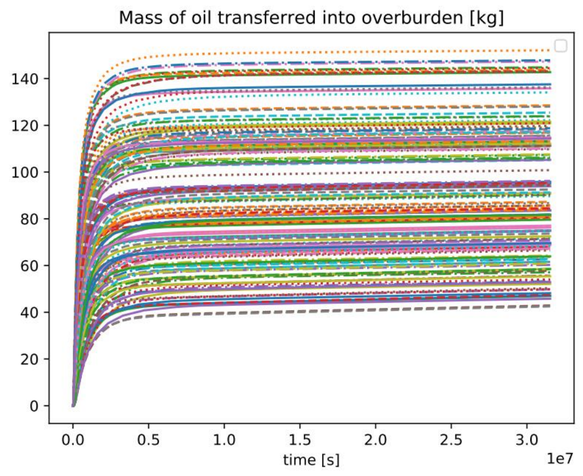


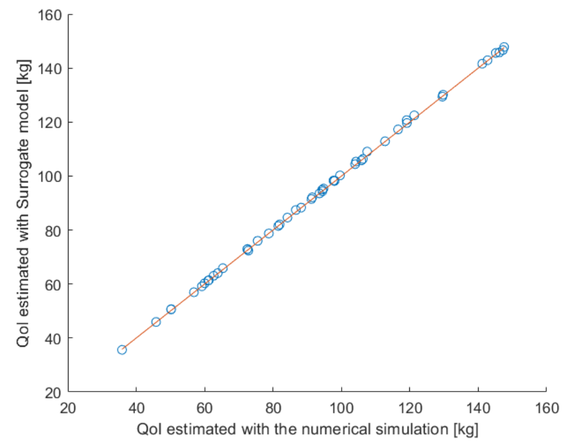
- Due to uncertainty of model parameters, risk is assessed in a probabilistic framework, relying on a Monte Carlo setting
- Considering the computational cost of the numerical simulations, **PCE-based surrogate models** are employed (evaluation based on sparse-grids or the quasi-Monte Carlo methodology).
- Surrogate models are assessed with additional simulations.

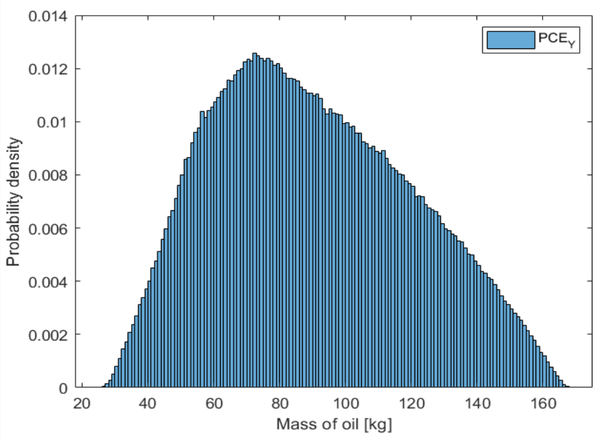
Results

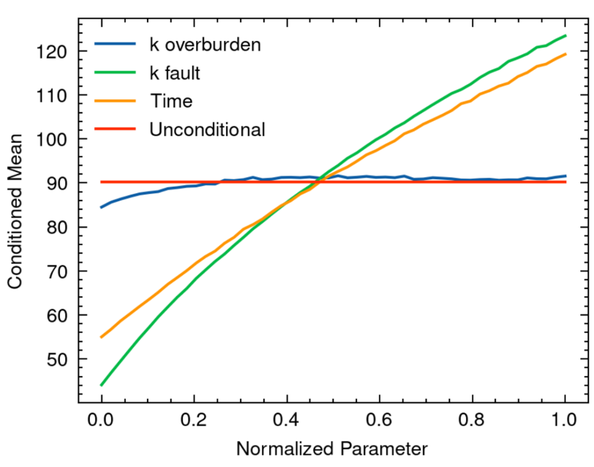
Scenario 2











Scenario 4

Scenario 4 results indicate that:

- The mass of HC (gas or oil) reaching the target aquifer is negligible for all combinations of uncertain model parameters considered in this study.
- The mass of water reaching the target aquifer is driven by the water displaced by the fluids introduced into the overburden in Scenario 2.
- Assuming that water within the overburden is saturated with methane, the mass of methane expected to be released to the atmosphere is approximately 52 tons (min 0 and max 120 tons).

CONCLUSION

- During the fracturing process, limited amounts of oil and gas are expected to be released to the overburden and this limits the impact of the risk scenarios that depend on the magnitude of the volumes of water release during the fracturing.
- Emissions are estimated to ~ 52 tons of Methane during a period of 100 years (with the bulk of the emission during the first 20 years).

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