Probabilistic exposure risk assessment with advective-dispersive well vulnerability criteria

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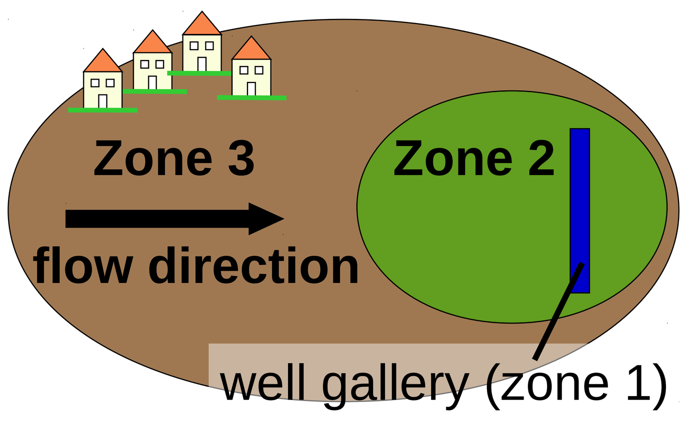
Motivation



According to current Water Safety Plans, water managers and stakeholders should ensure safe drinking water supply by controlling the risk from catchment to tap through a preventive risk management concept: *(1) What kind of hazards exist within the water catchment, (2) how these hazards can be controlled and (3) knowing that they are controlled.*
We aim to develop a concept, providing the fundamental basis for probabilistic risk assessment (PRA) in actively managed well catchments. Thus we can provide stakeholders with the necessary information and tools to develop complete risk management schemes.

Approach

Our probabilistic intrinsic transport-based well vulnerability criteria are:

(a) The probability distribution of peak arrival time from source to well;

(b) Possible levels of peak concentration arriving at the well;

(c) Probability distribution of reaction time until a threshold level is exceeded (e.g., drinking water standard); and

(d) The probability distribution of well down time (exposure time).

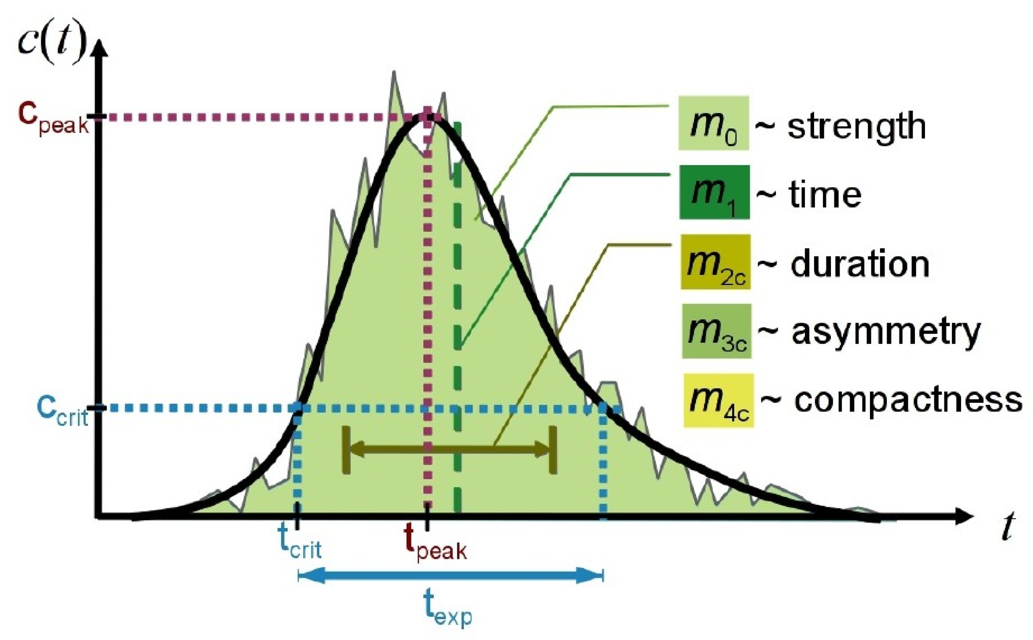


Figure 1: Illustrative sketch showing the four intrinsic well vulnerability criteria and temporal moments characterizing the concentration BTC c(t)

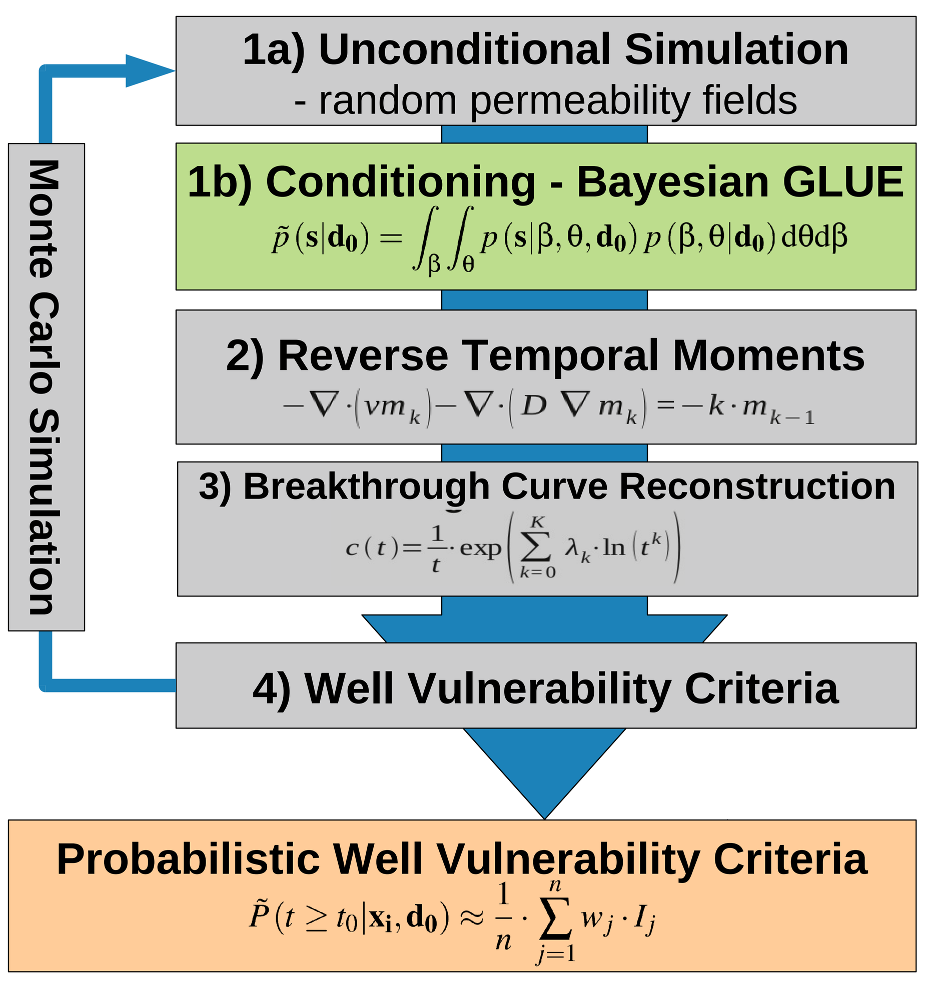


Figure 2: Methodology to determine probabilistic intrinsic well vulnerability criteria

Illustrative Example

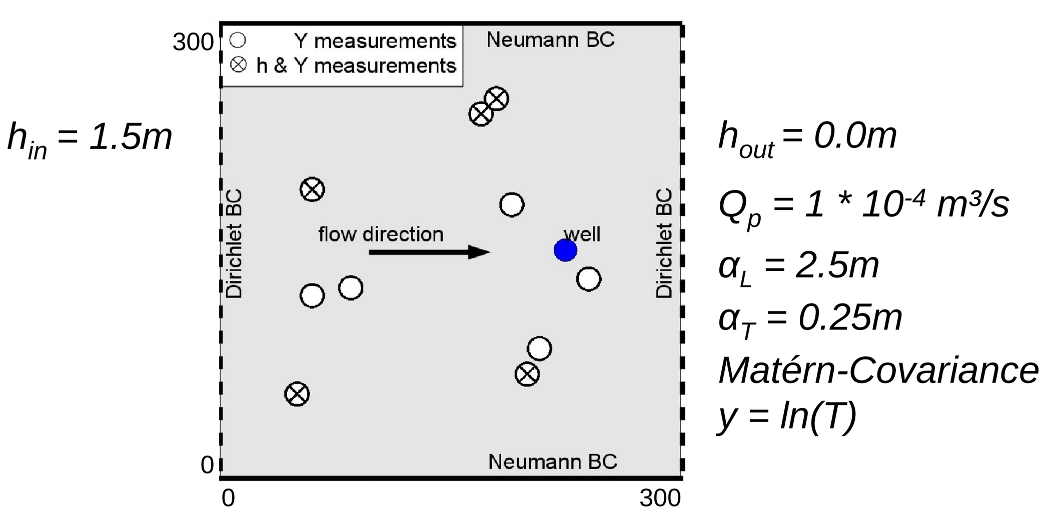


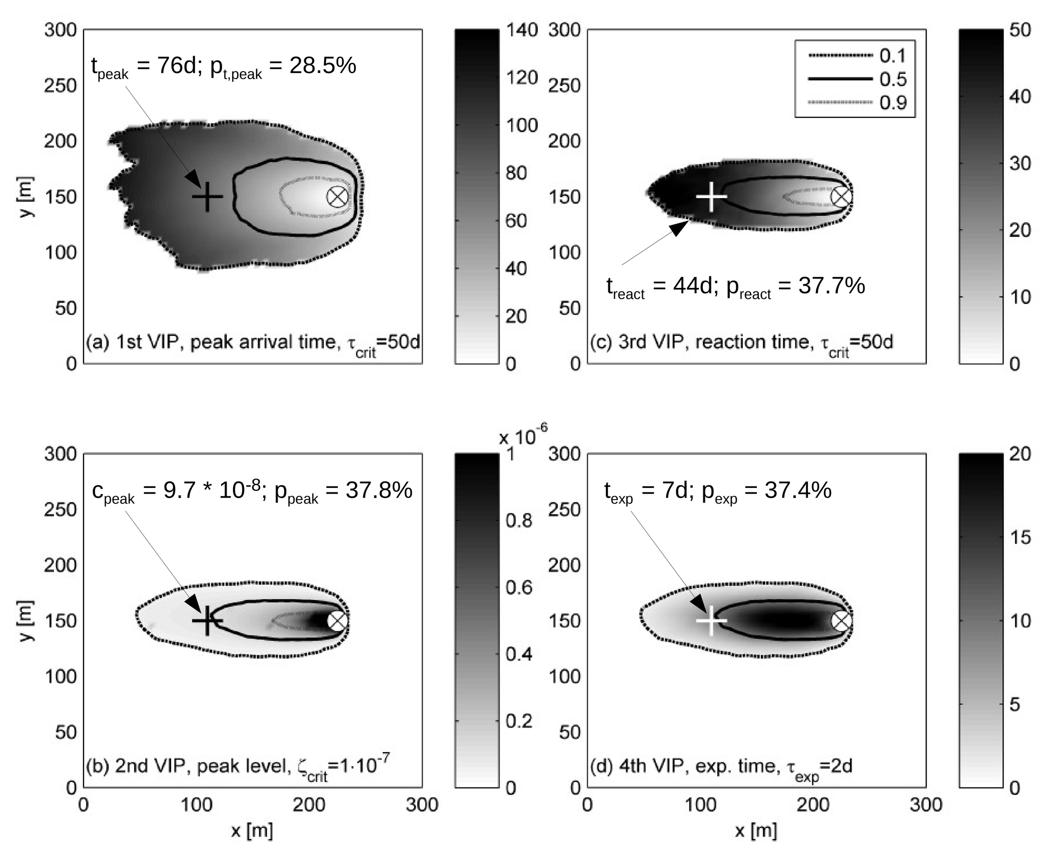
Figure 3: Illustrative Example, showing location of measurements

	value	unit
μ_y	[-7.5 -5.5]	[-]
σ^2_y	[1 3]	[-]
κ	[0.5 5]	[-]
λ_x	[10 25]	[m]
λ_y	[5 15]	[m]
q_{rg}	120	mm a^{-1}
σ_{rg}	10	mm a^{-1}

Table 1: Uncertain model parameters

Conditional Results

Figure 4: Probabilistic isopercentiles [0.1, 0.5, 0.9] for the four intrinsic well vulnerability criteria (a)-(d) from n=500 simulations. Grey-scale maps show the ensemble mean of the respective well vulnerability criteria.



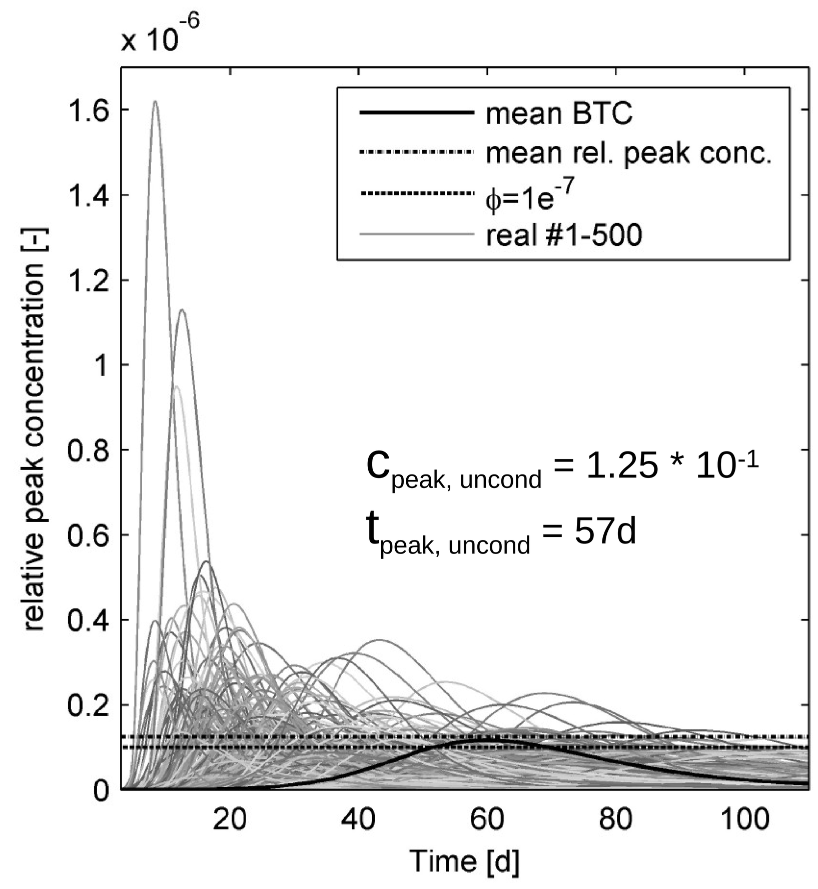
Effect of Conditioning: (U = $(A_{10}-A_{90})/A_{50}$)

Table 2: Showing the fractional area [%] of delineated catchments according to the four VIP maps that is sacrificed to uncertainty for the conditioned and the unconditioned case.

VIP	„critical value“	Unconditional uncertainty U_{uc}	Conditional uncertainty U_c
t_{peak}	τ_{crit} = 50d	43.1%	25.2%
c_{peak}	ς_{crit} = 1 x 10^{-7} [-]	14.6%	10.4%
t_{crit}	τ_{crit} = 50d	14.6%	10.4%
t_{exp}	τ_{exp} = 2d	14.5%	10.3%

Why macro-dispersion is inadequate for PRA:

Figure 5: BTC of all realizations and the average breakthrough curve (bold) of n = 500 unconditional realizations at the drinking water well, if a hazardous spill occurred at location A.



Outlook

- Optimal site exploration for minimal uncertainty in probabilistic well vulnerability criteria.
- Risk concept for long-term sources and transients (e.g., varying pumping schedule in cooperation with DTU).
- Risk Analysis (FTA, …).

Literature

[1] *Enzenhöfer, R., Nowak, W. and Helmig, R.:* Probabilistic exposure risk assessment with advective-dispersive well vulnerability criteria. Advances in Water Resources, submitted, (2010)

[2] *Frind, EO; Molson, JW and Rudolph, DL: Well vulnerability:* A quantitative approach for source water protection. *Ground Water Vol. 44 No. 5 (2006), p. 732–742*

[3] *Feyen, L.; Ribeiro, PJ; Gomez-Hernandez, JJ; Beven, KJ and De Smedt, F.:* Bayesian methodology for stochastic capture zone delineation incorporating transmissivity measurements and hydraulic head observations. *Journal of Hydrology Vol. 271 No 1-4 (2003), p. 156–170*

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