Pathline Density Distributions in a Null-Space Monte Carlo Approach to estimate Groundwater Pathways for a Major Water Supply System

C. Moeck[1], J. Molson[2], & M. Schirmer[1,3] ; [1] EAWAG, Swiss Federal Institute of Aquatic Science and Technology , Dübendorf, Switzerland **(christian.moeck@eawag.ch)**
[2] Département de géologie et de génie géologique, Université Laval, Québec, Canada; [3] Centre of Hydrogeology and Geothermics (CHYN), University of Neuchâtel, Neuchâtel, Switzerland

Background

Particle tracking (PT) is commonly applied to identify contaminant source locations and pathways.

Problem

The basic PT approach, **does not consider subsurface uncertainty** which can lead to misleading results.

Study area

Important water supply site where drinking water supply is combined with artificial infiltration

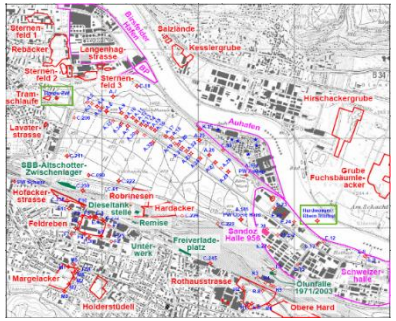
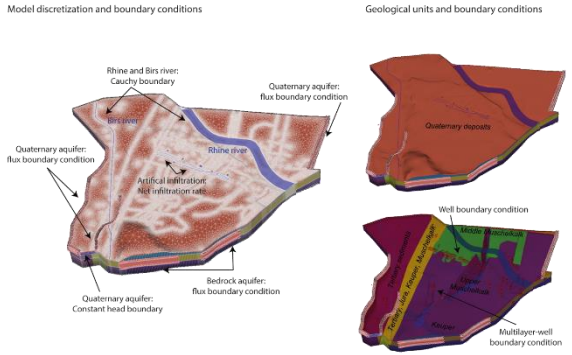


Fig. 1: Contaminated areas in red and green letters, 32 drinking water pumping wells are shown as red points

Methodology

Numerical 3D model (Feflow)



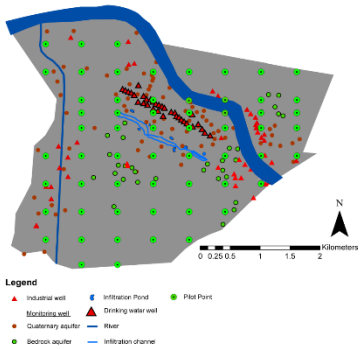
Model calibration with Pilot Points (PEST)

116 monitoring wells (82 sand–gravel aquifer; 34 in bedrock aquifer)

60 Pilot Points for each of the six model layers

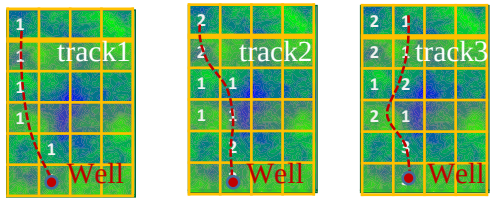
1000 different initial random parameter sets

Parameters in the solution space are calibrated and Null-space parameters are random (untouched).



Backward particle tracking density

Running the model with all accepted parameter realization and track particles



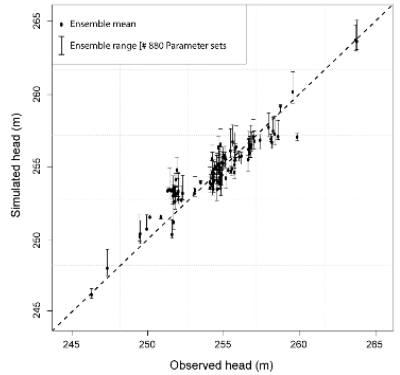
Results I

Model calibration

Small systematic over-estimation

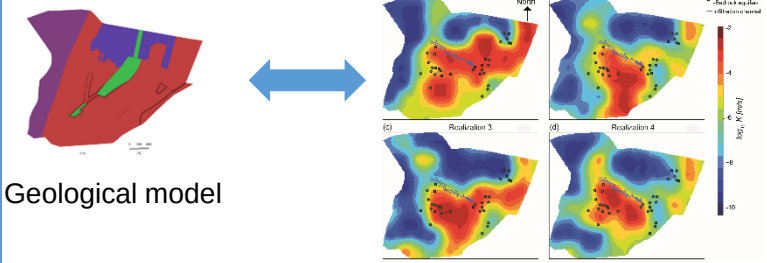
Residuals are within 0.0 < |r| < 0.5 m

Only parameter sets (88%; i.e. 880 parameter sets) < target function during the calibration are considered.



Results II

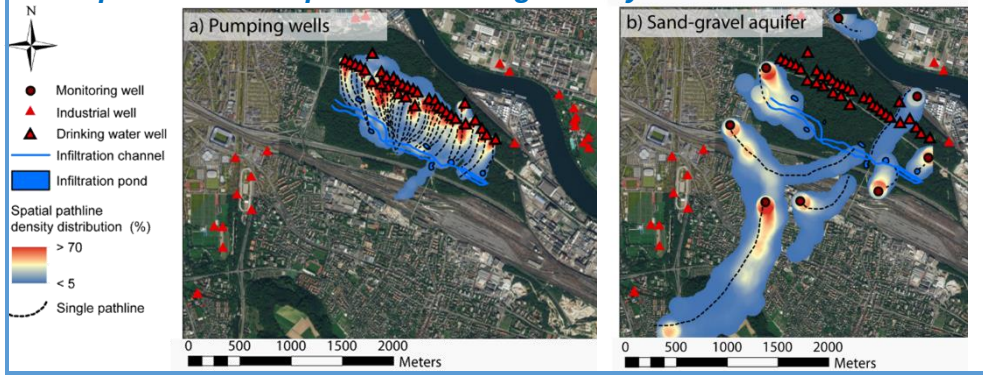
K distribution for the bedrock



Geological model

Example: 4 out of 880 stochastic parameter fields

Example: Backward particle tracking density



Conclusion

PT without Monte-Carlo → not representing subsurface uncertainty and will always provide smaller well capture zones.

PT based on a single flow simulation → can be used as initial screening tool, however, decisions should not be based on only one model realization.

Our pathline density distributions, following a simple post-processing step → provide probability information maps beyond classical deterministic PT approaches.

Reference:
Moeck, C., Molson, J. and Schirmer, M. (2020), Pathline Density Distributions in a Null-Space Monte Carlo Approach to Assess Groundwater Pathways. Groundwater, 58: 189-207. doi:10.1111/gwat.12900