A generic modeling exercise to identifying factors influencing the representativity of measured pesticide concentrations at groundwater monitoring wells

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Introduction

Measured concentrations of active substance(s) and/or metabolites at groundwater monitoring wells can be affected by geometry and location of fields treated with plant protection products. A generic modeling exercise was conducted to investigate the influences of shape, location and size of treated fields, to identify important factors for the representativity of measured concentrations with respect to the treated upstream area.

Methods and Scenarios

Two scenarios with different configurations of treated fields were simulated by coupling the leaching model FOCUS-PEARL (4.4.4) with the open-source software OpenGeoSys (Ref. 1).

- **Scenario 1** (Figure 3): Three application fields with different areas, coverage of the upstream flowpath (covering length) and distances to the monitoring well.
- **Scenario 2** (Figure 6): Application fields with increasing covering lengths along principle groundwater flow direction. Otherwise the model setup is the same as Scenario 1.

Leaching simulations for the fields were carried out using FOCUS-PEARL Hamburg scenario (Ref. 2) with product applications every third year. The concentrations of PPP metabolites and the volume fluxes of water calculated in the leaching simulations were used as the upper boundary conditions for the subsequent two-dimensional groundwater flow and solute transport simulations carried out using OpenGeoSys, in which resulting concentrations at a downstream monitoring well were calculated.

Figure 1 Schematic representation of PPP transport in the subsurface below a treated field

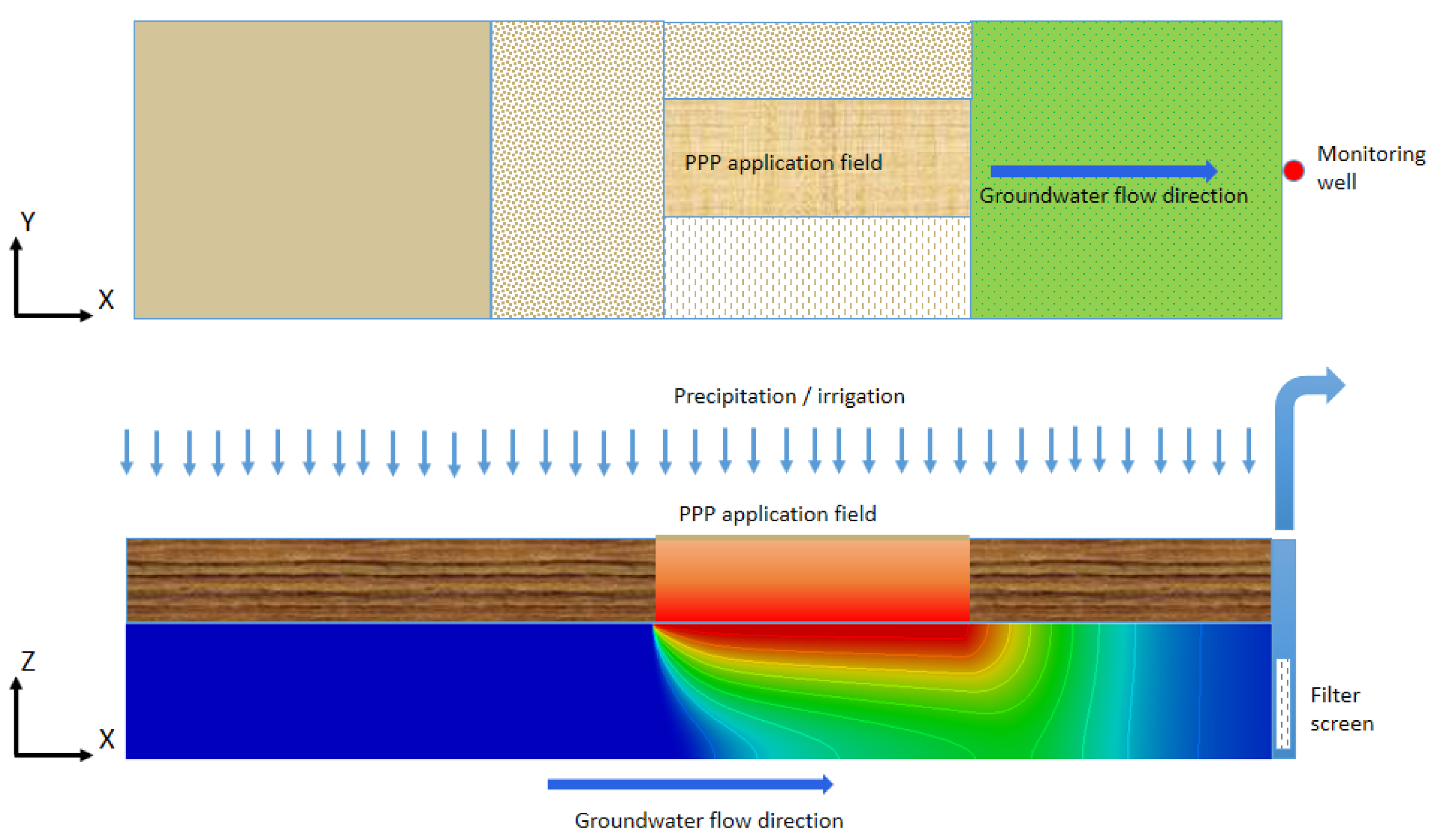
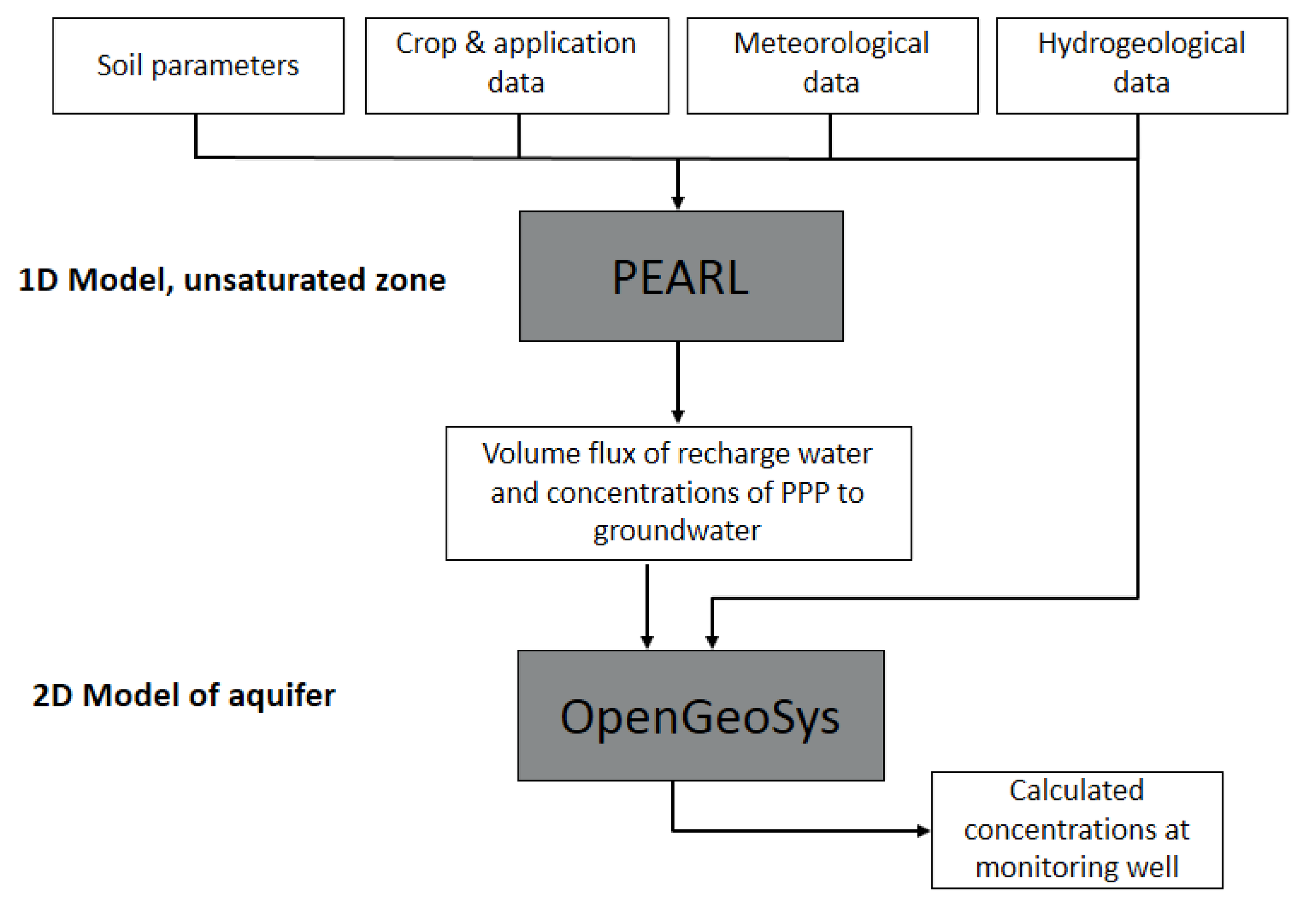


Figure 2 The coupling concept between PEARL and OpenGeoSys



Results and Discussions

- **Scenario 1**:
  The time series of simulated concentrations for the three fields at a monitoring well with a shallow filter screen are illustrated in Figure 4. Fields 2 and 3 result in effectively identical concentrations at the well, despite very different covering lengths on the upstream groundwater flow path. The breakthrough curve at the well from each application to Field 1 is later due to the greater travel distance to the well, with lower peak concentrations as the concentration plume depth increases along the flowpath and a portion of the plume passes below the shallow filter screen.
- **Scenario 2**:
  The simulated concentrations for fields with different covering lengths along the principal groundwater flow direction ranging from 50 to 850 m are illustrated in Figure 6. With a field length of 50 m already ~75 % of the maximum concentration is reached, and ~90% with 150 m field length. No significant increase of the measured concentration was observed for fields with a covering length above 250 m.

Table 1 Hydrogeological parameters for the aquifer

Parameter	Unit	Value
Hydraulic conductivity	$m\ s^{-1}$	0.0002
Effective porosity	-	0.175
Longitudinal dispersivity	m	1
Transverse dispersivity	m	0.1

Conclusions

- The total area of treated fields upstream of the well is not necessarily the determining factor for measured concentrations at monitoring wells.
- The coverage of the upstream flow path where there is a hydraulic connection to the filter screen of the monitoring well is a key factor influencing measured concentrations at the well.
- If the coverage of treated fields along an axis which is connected to the well and aligned with the groundwater flow direction reaches a certain threshold length, a further increase of the treated areas along that axis will not lead to higher measured concentrations at the well.

Figure 3 Schematic presentation of Scenario 1: three application fields with different shapes and locations

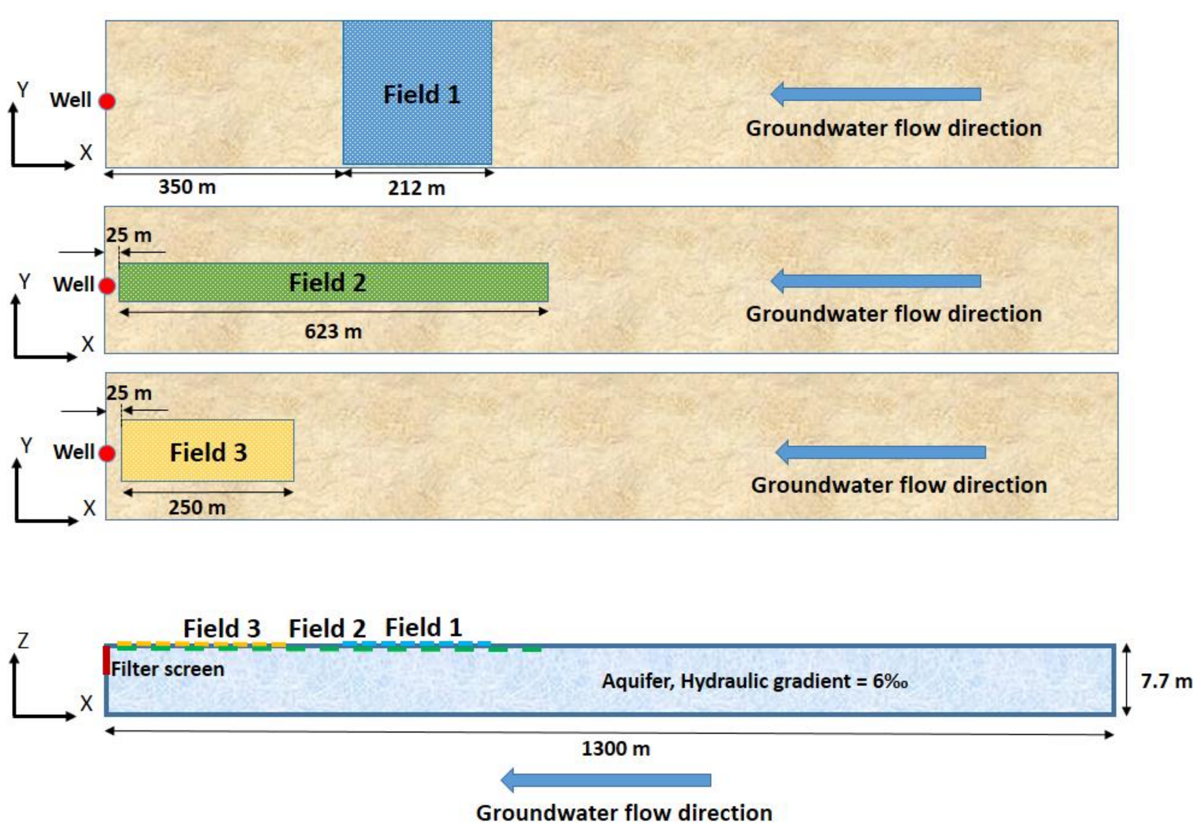


Figure 4 Simulated concentrations at the monitoring well with a shallow filter screen (s. Figure 3)

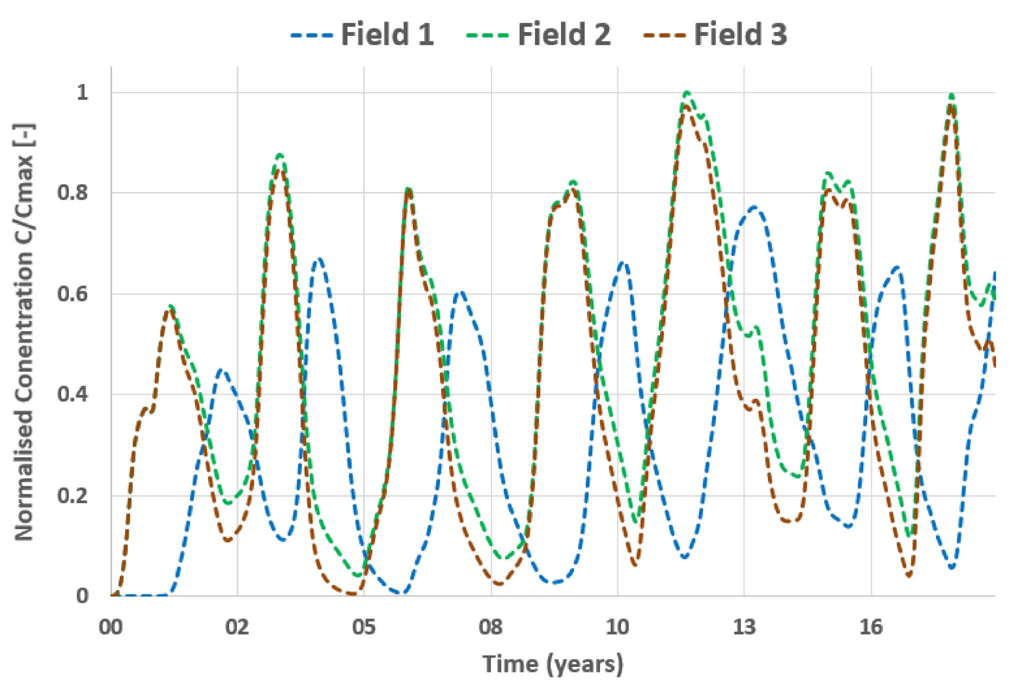


Figure 5 Schematic presentation of Scenario 2: Fields with increasing covering length along the principle groundwater flow direction

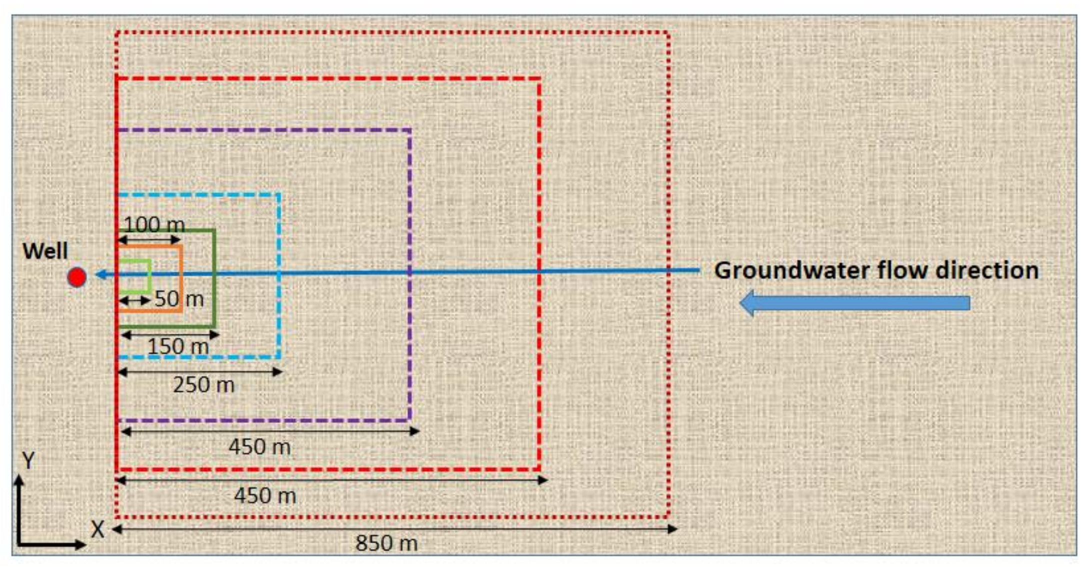
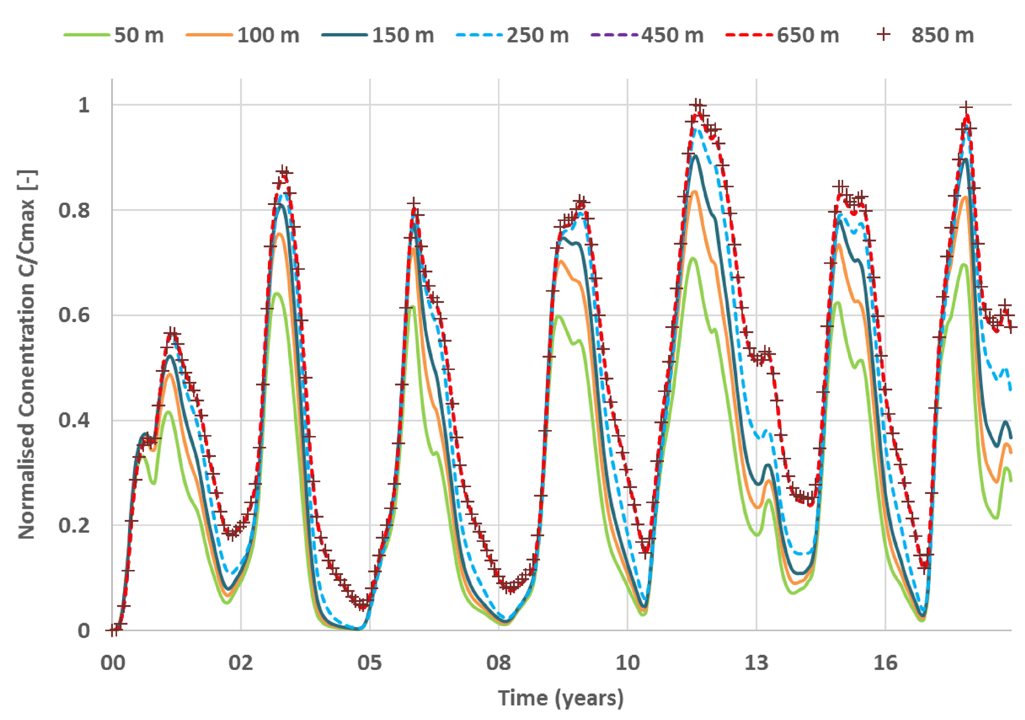


Figure 6 Simulated concentrations at the well for fields with different covering lengths along the principle groundwater flow direction (s. Figure 5).



References

Ref. 1 Kolditz, O., Bauer, S., Bilke, L., Böttcher, N., Delfs, J.O., Fischer, T., Görke, U.J.,Kalbacher, T., Kosakowski, G., McDermott, C.I., Park, C.H., Radu, F., Rink, K., Shao, H., Shao, H.B., Sun, F., Sun, Y.Y., Singh, A.K., Taron, J., Walther, M., Wang, W.,Watanabe, N., Wu, Y., Xie, M., Xu, W., Zehner, B. (2012): OpenGeoSys: an open-source initiative for numerical simulation of thermo-hydro-mechanical/chemical (THM/C) processes in porous media, Environ. Earth Sci.

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