Modeling ground water and benzene discharge to a river from an alluvial aquifer subject to strong interactions with surface water

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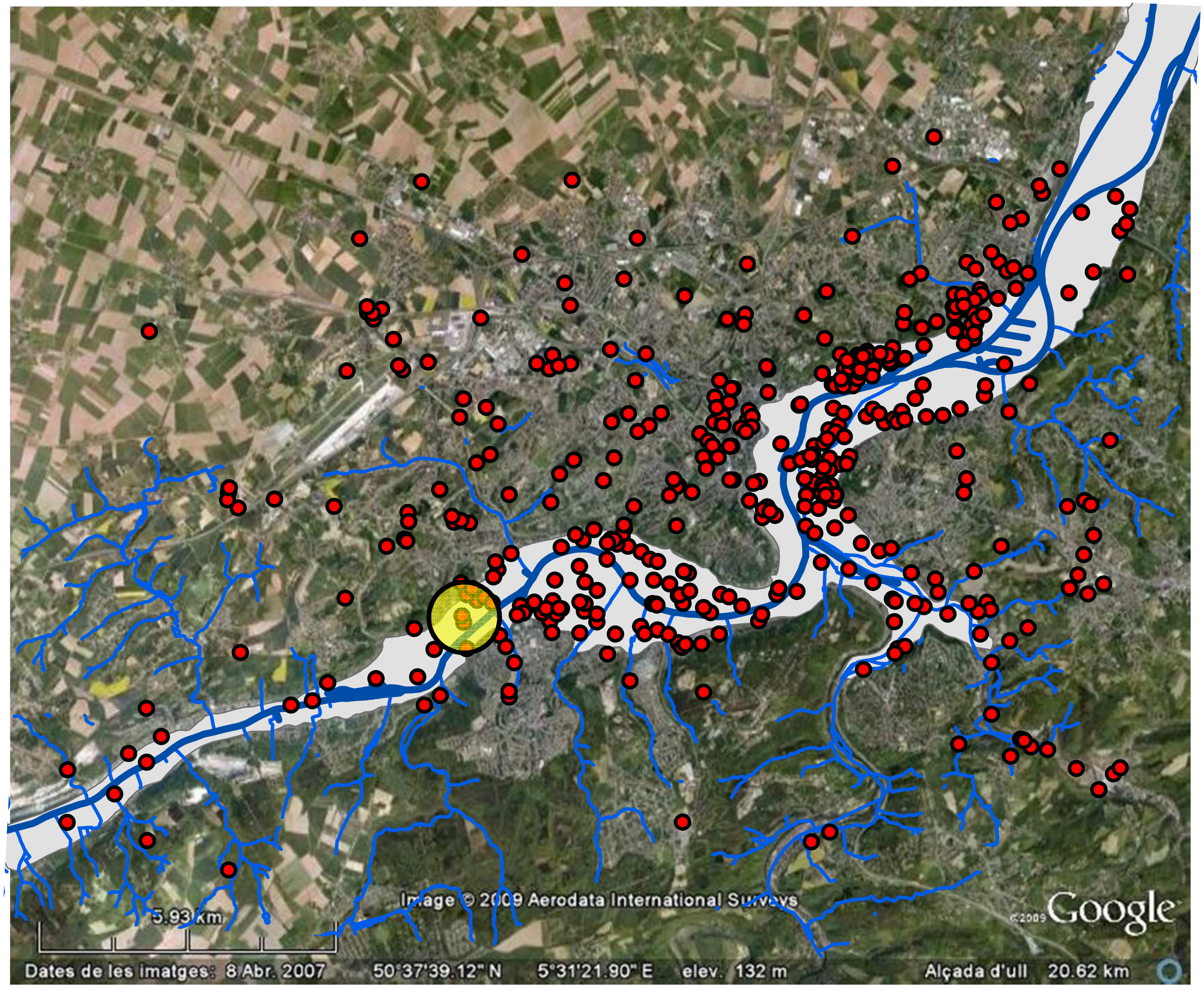
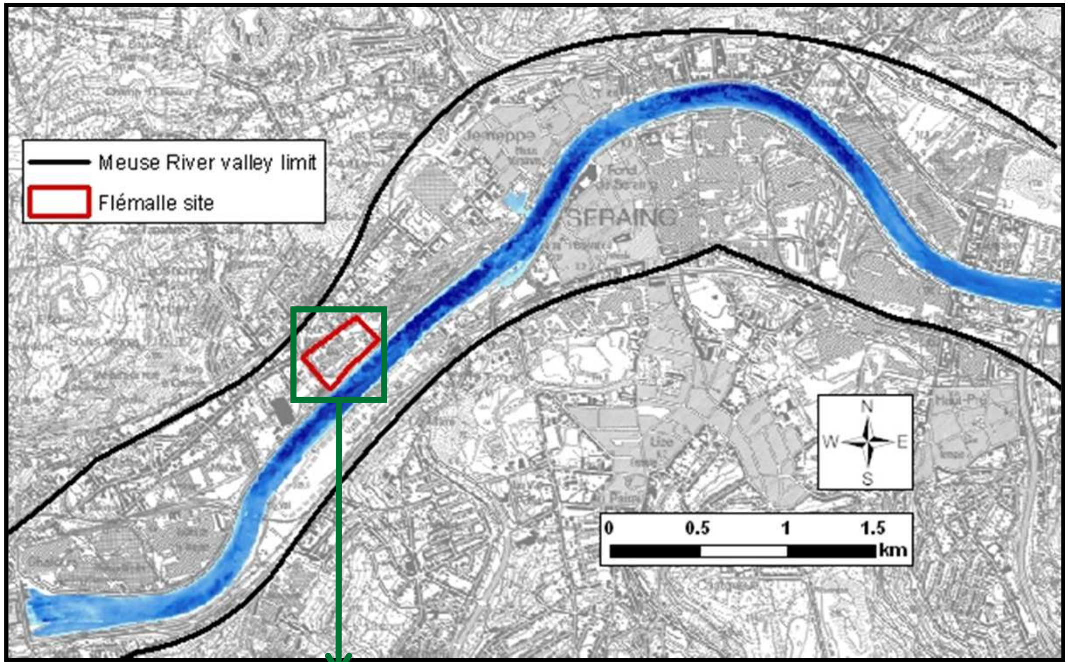
Research context



Research context



- Alluvial aquifer;
- Proximity to the Meuse River (25 m);
- Pollutant industrial activities (1922 – 1984);
- Soil and groundwater highly polluted by organic (BTEX and PAHs) and inorganic (metals, Fe and sulphate) components.

Challenge

At regional scale hydrogeological data is scarce, and hydrogeological investigations (e.g. pumping tests) are difficult to perform because of the pollution of groundwater and river perturbations to these tests.

Objective and methodology

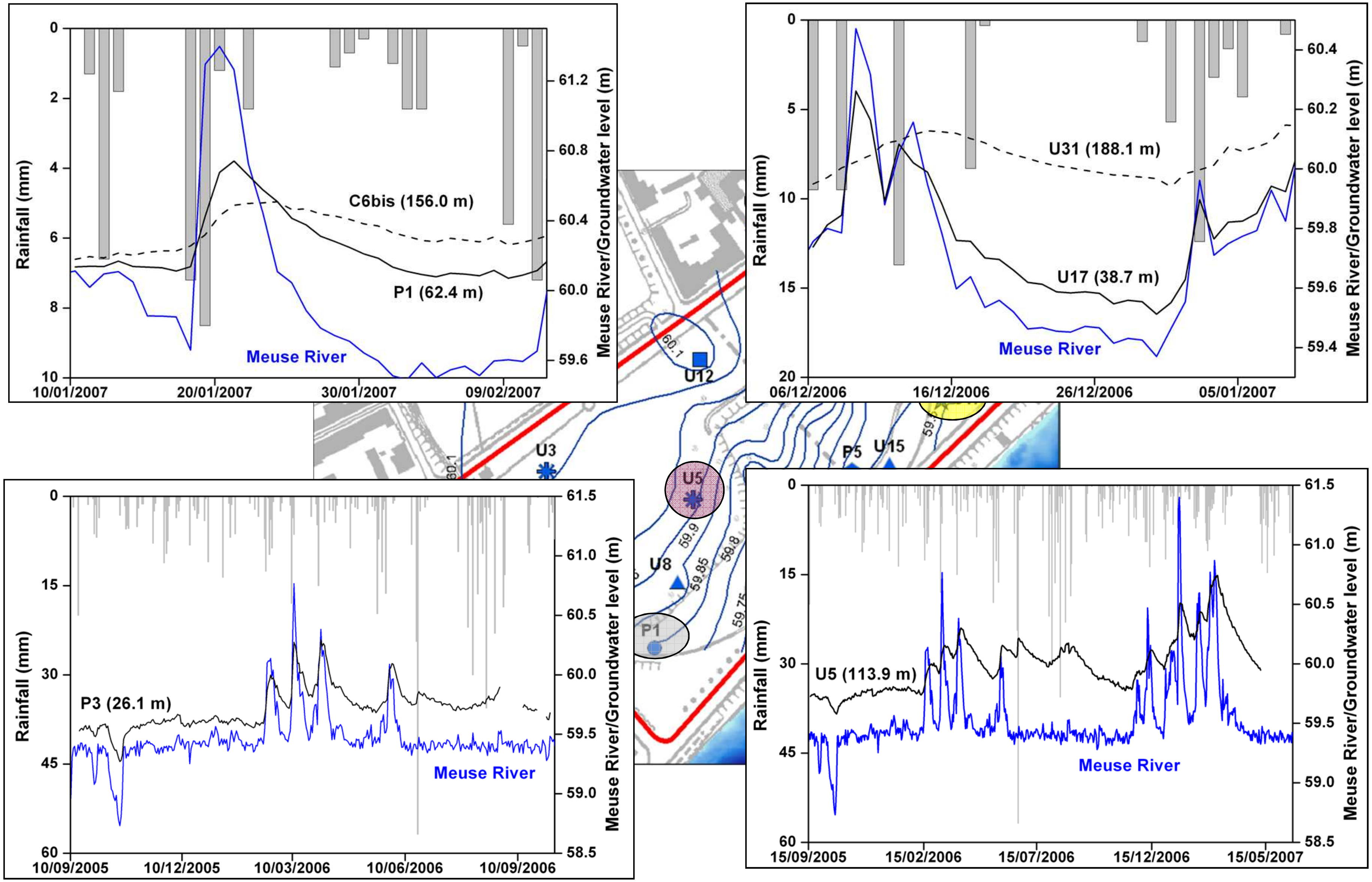
To assess, as accurately as possible, the spatial dsitribution, amplitude and dynamics of groundwater fluxes. This will be done based on:

- ✓ Long term monitoring of groundwater – surface water dynamics,
- ✓ combined (regional) zonation – (local) pilot points parameterisation of aquifer heterogeneity.

To achieve this goal, the methodology should consider:

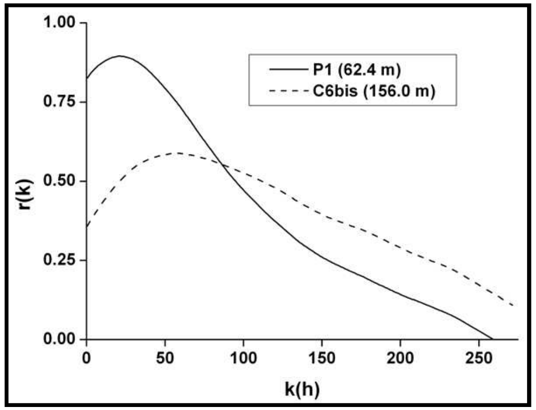
- ➢ Flexible and reliable representation of groundwater levels and gradients,
- ➢ accurate representation of the *K*-field (amplitudes and spatial patterns),
- ➢ reliable calibration of the GW model using appropriate observations and measurements performed in the field (pumping tests impossible to perform and not reliable).

Monitoring works

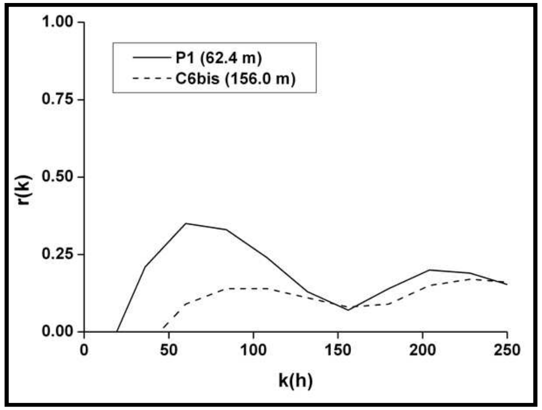


Monitoring works

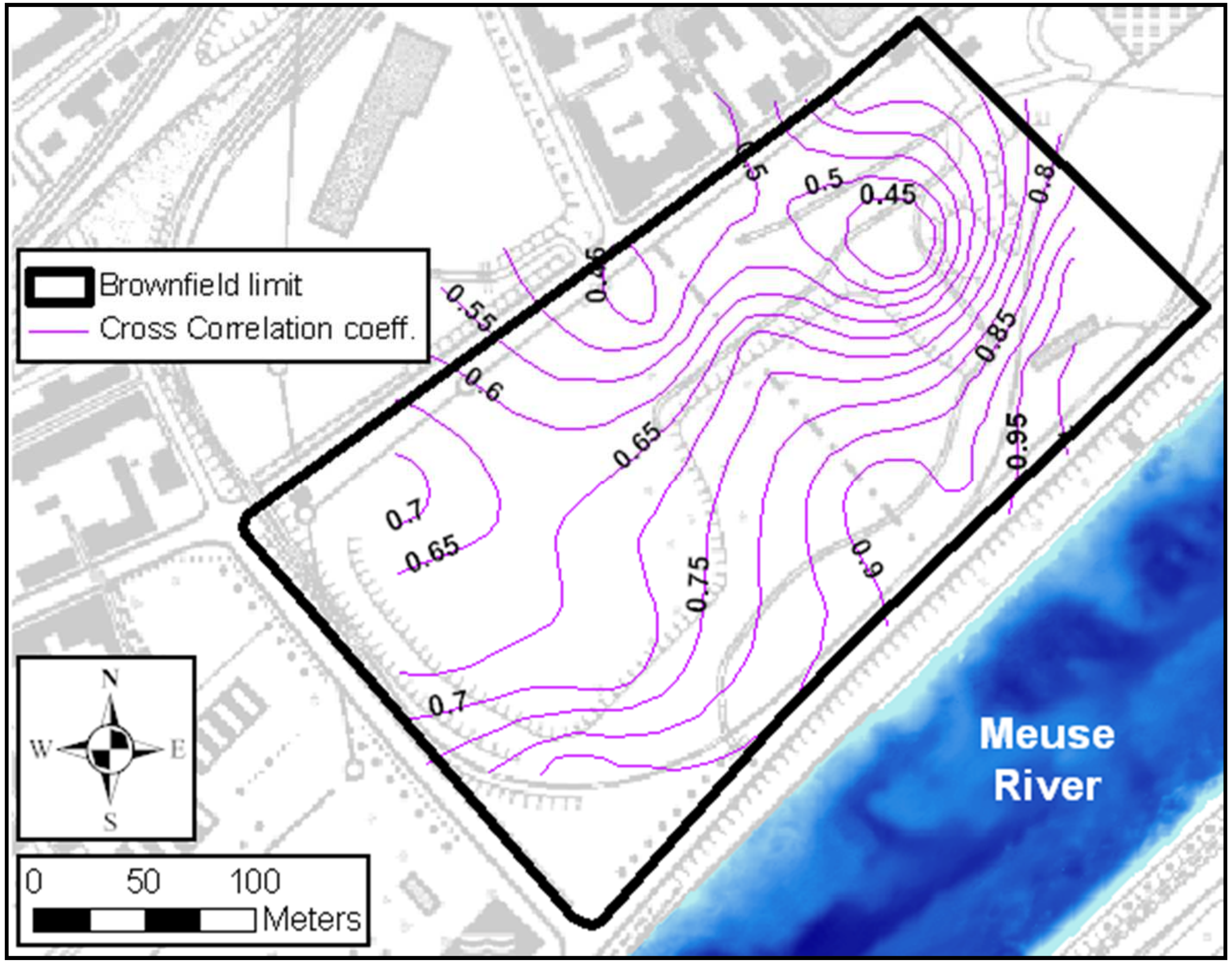
Cross-correlation analysis



River water level – ground water level



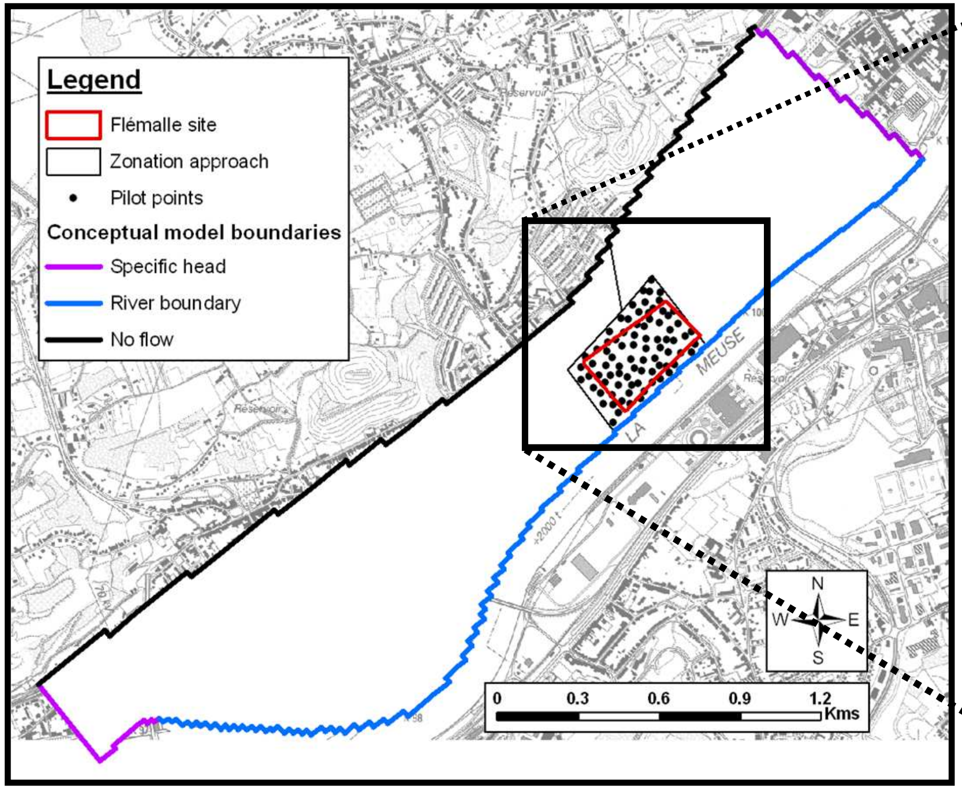
Rainfall– ground water level

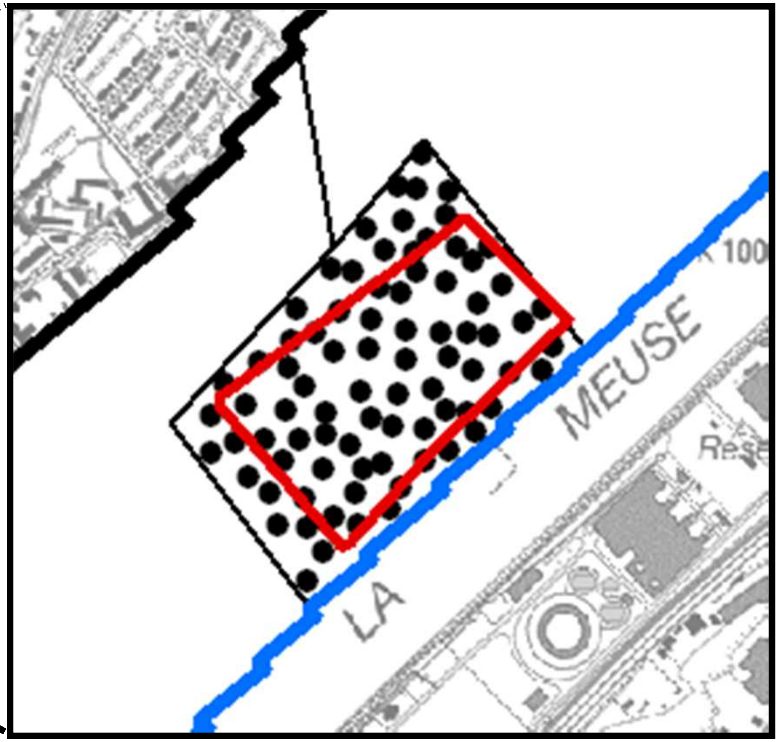


Ground water flow modeling concepts

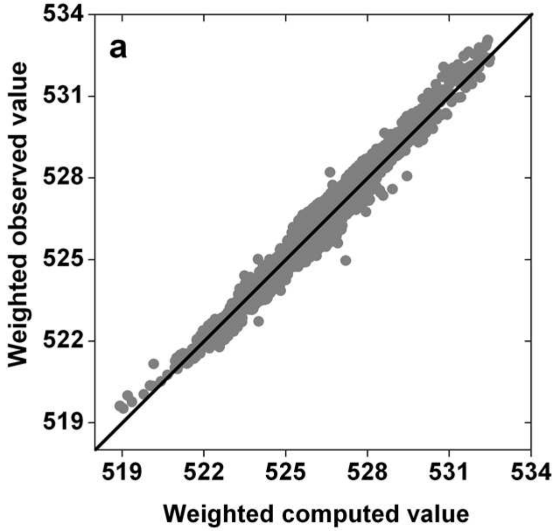
MODFLOW-2000 with inverse modeling implemented with PEST, using zonation (regional) and pilot points (local) approaches as parameterisation techniques

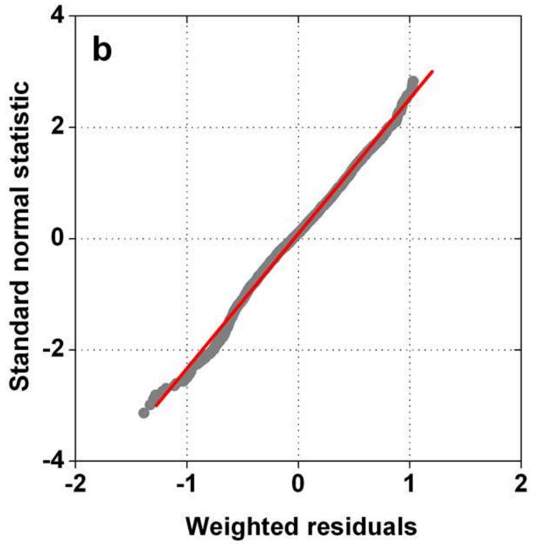
Pilot points (de Marsily *et al*., 1984) results in a smoothed variation of the hydraulic property over the model domain.



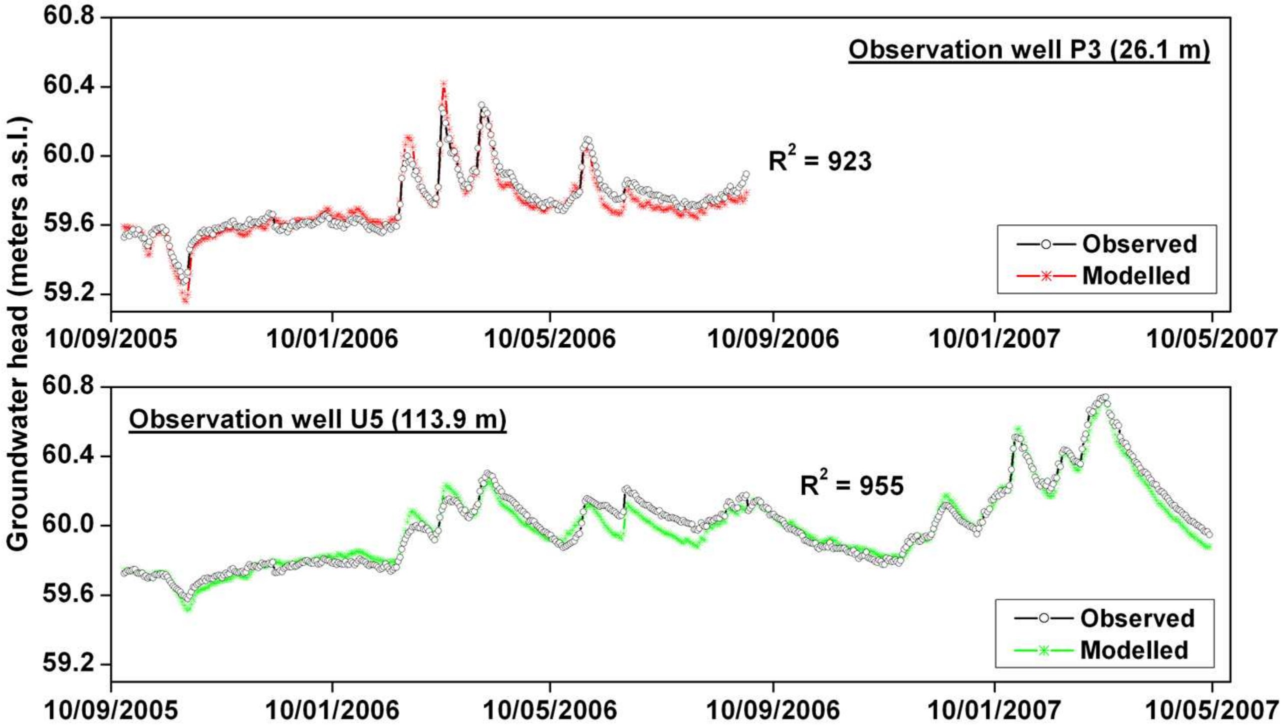


Groundwater flow modeling results



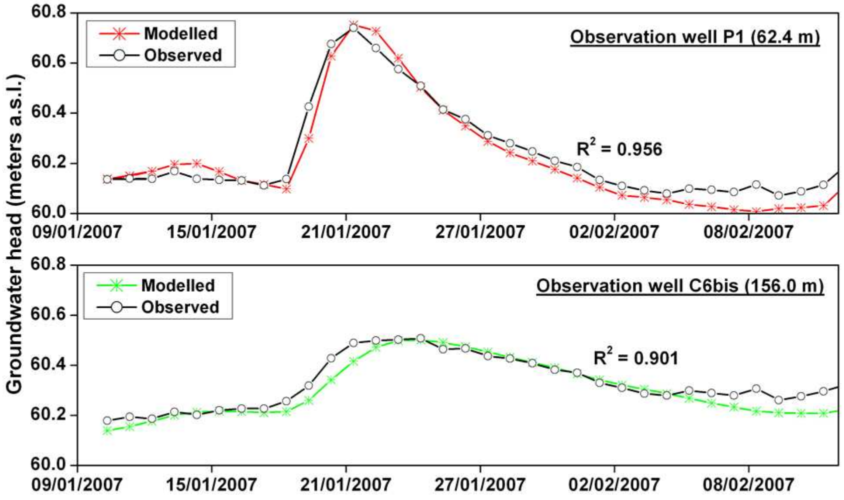


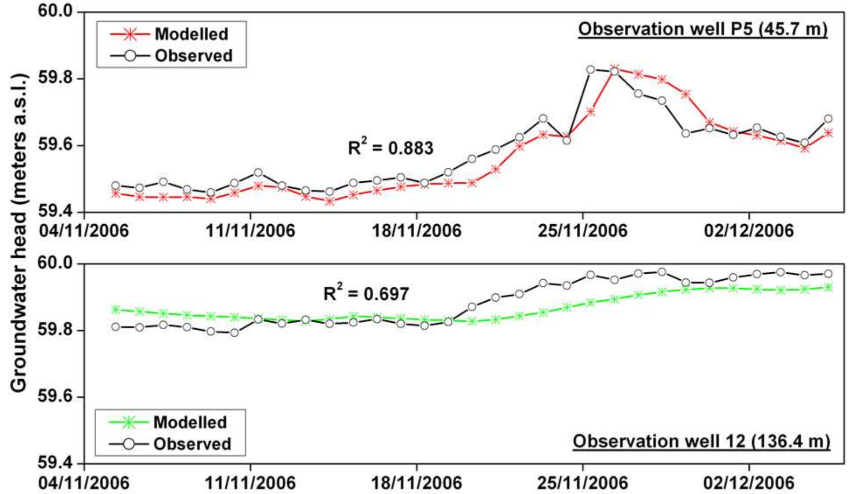
RMSE Observed vs. Computed GW heads: **0.048 m.**

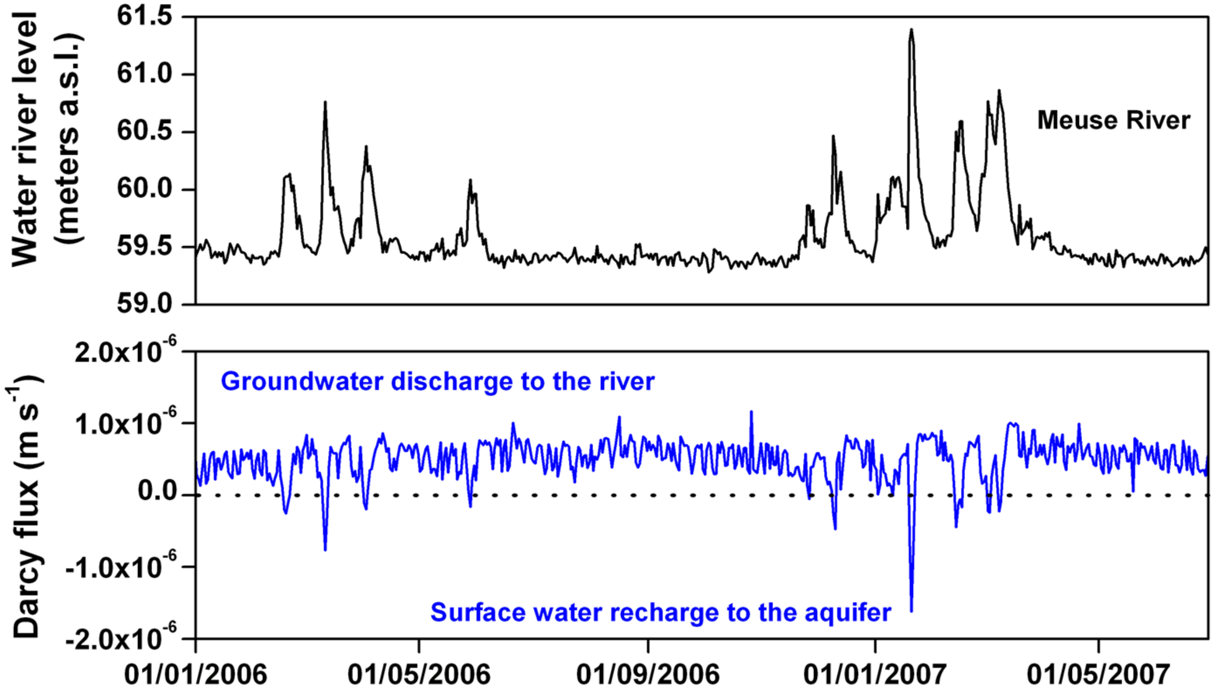


Groundwater flow modeling results

Batlle-Aguilar *et al.* (*J. Hydrol.*,369: 305-317, 2009)

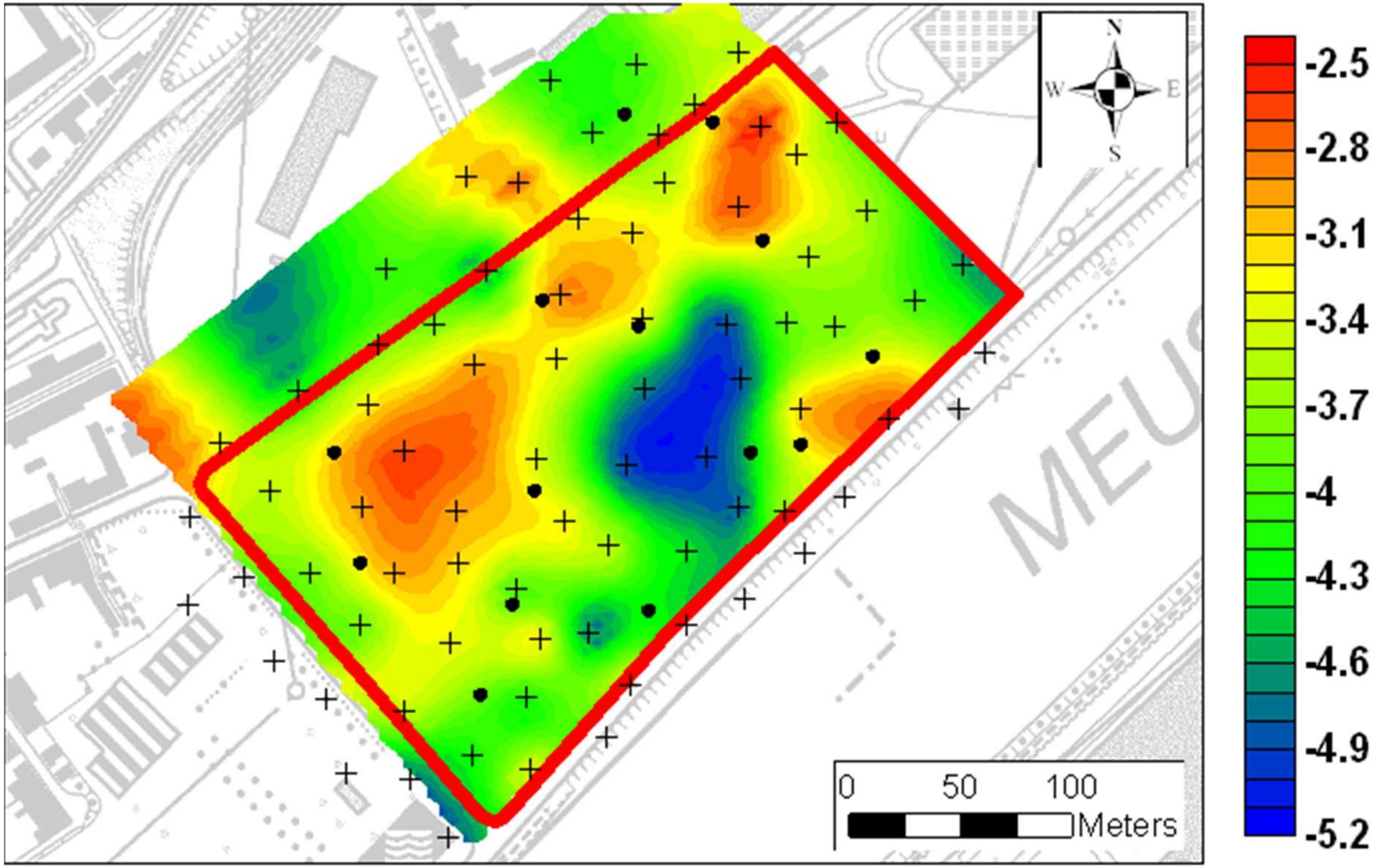






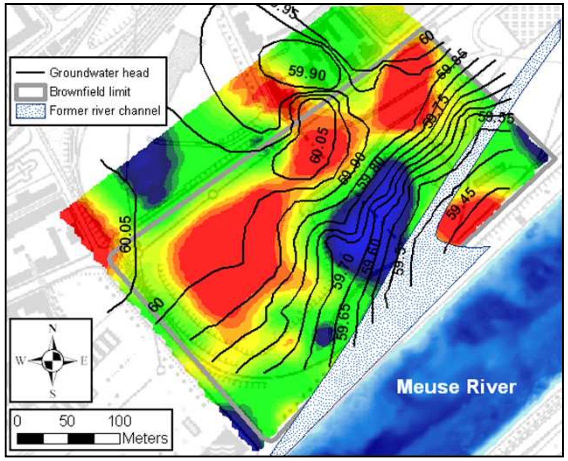
Heterogeneity *K*-field validation

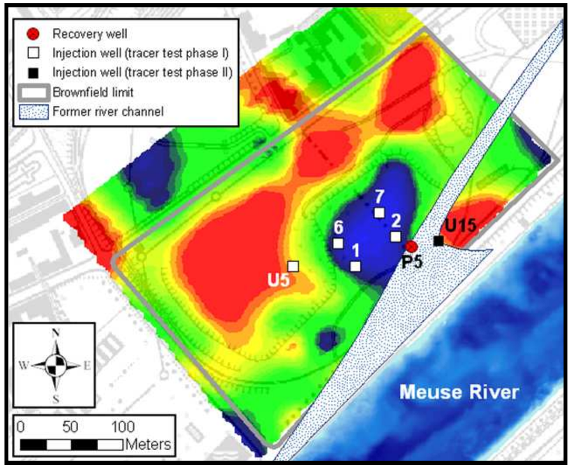
Spatial distribution of the $\log_{10}$ *K*-field

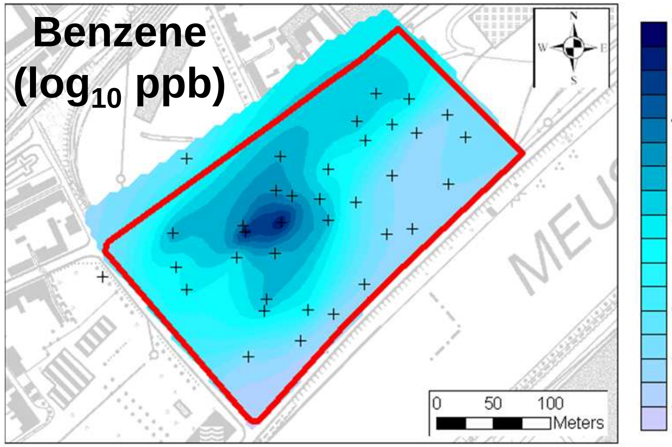


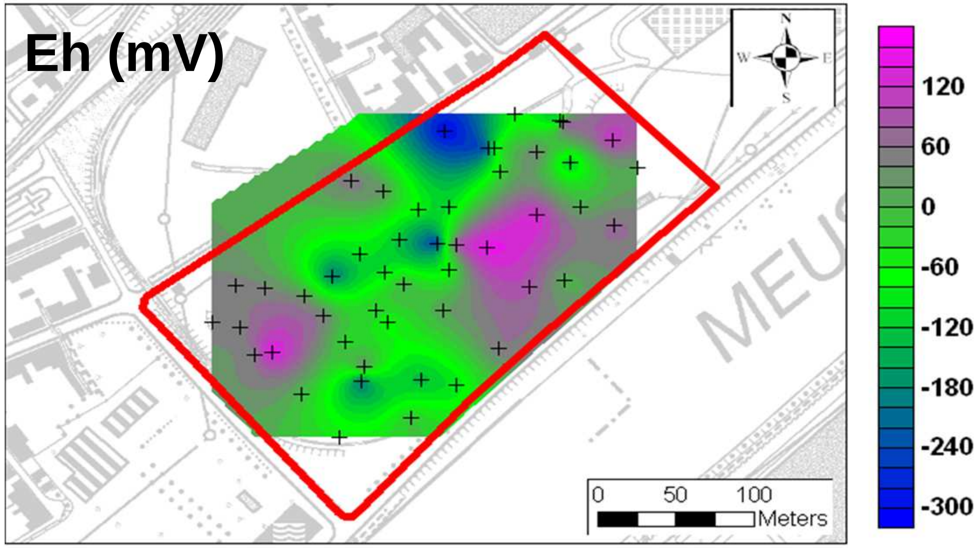
(Batlle-Aguilar, 2008; Ph.D thesis)

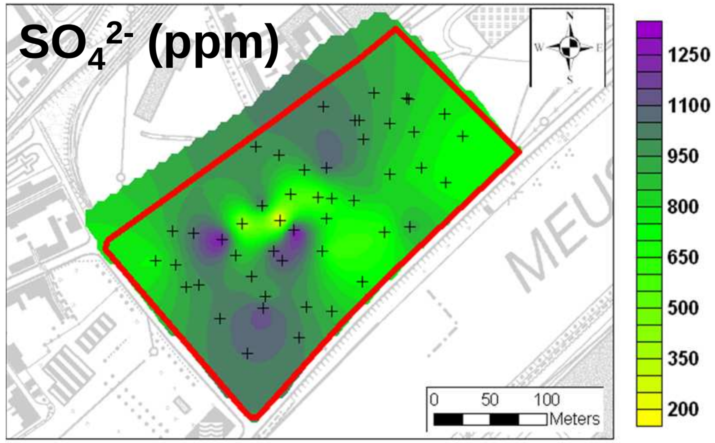
Heterogeneity *K*-field validation











(Batlle-Aguilar, 2008; Ph.D thesis)

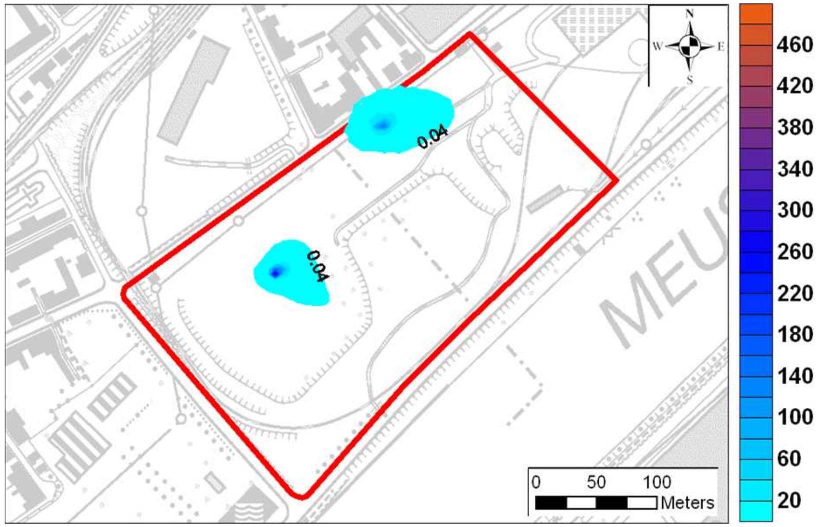
Benzene transport

Transport model (MT3DMS) calibrated fitting measured breakthrough curves in radially convergent tracer tests.

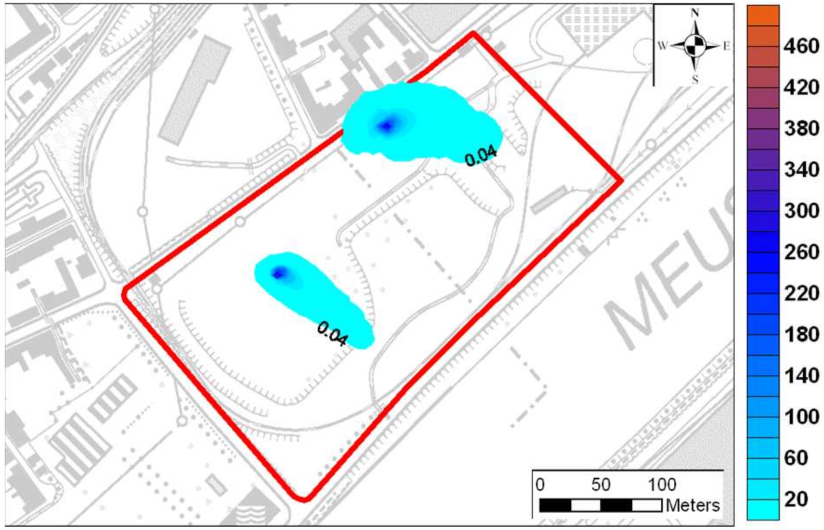
- Advection - dispersion equation (ADE).
- Longitudinal dispersion (α_L).
- Dual porosity effects (MIM).
- First order benzene biodegradation.
- Estimated *in-situ.*
- Stable carbon isotope analysis.

(Batlle-Aguilar, 2008; Ph.D thesis)

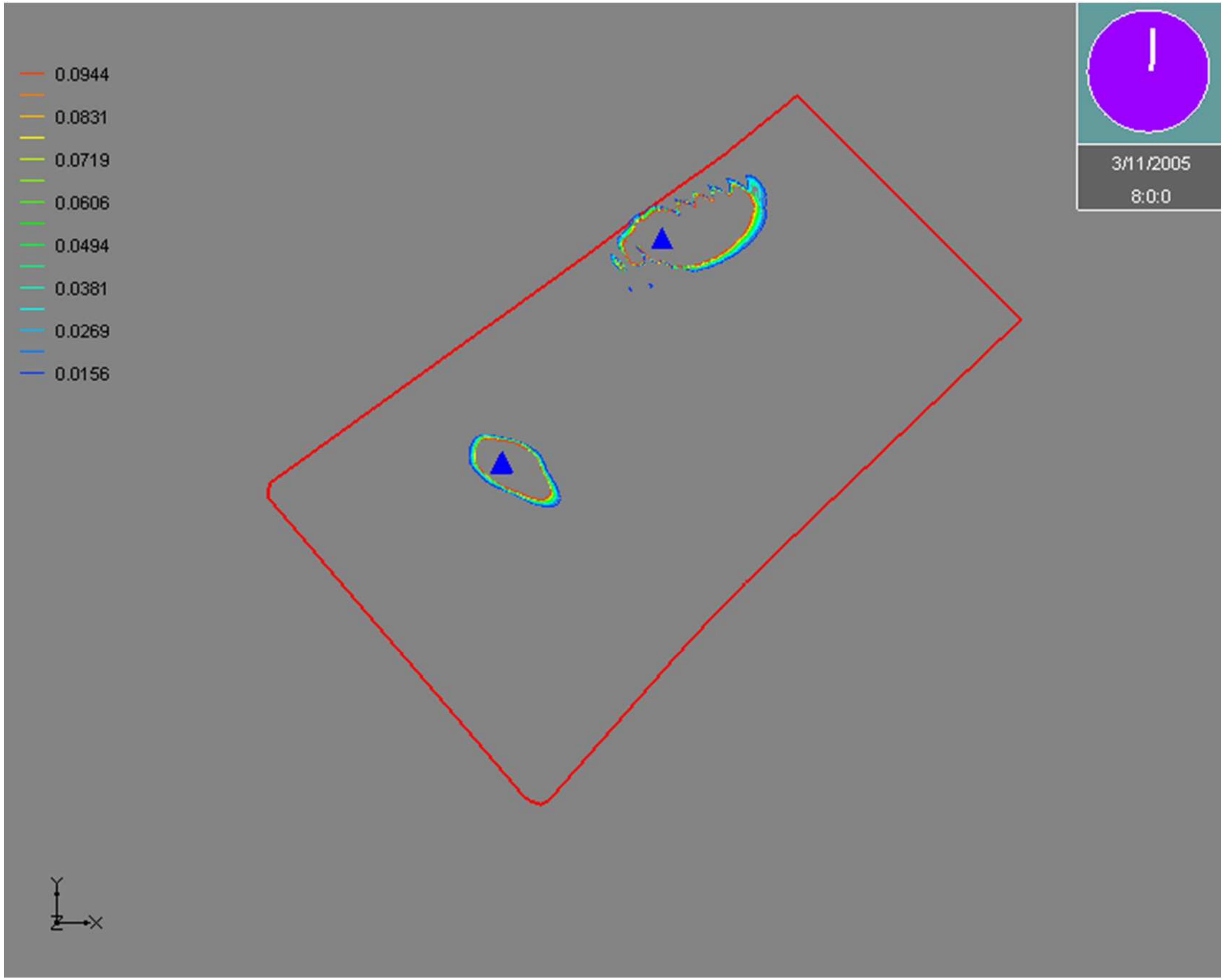
High river water level



Low river water level



Benzene transport



(Batlle-Aguilar, 2008; Ph.D thesis)

Conclusions and perspectives

• Methodology well adapted to avoid regional data scarcity and difficulties in performing local hydrogeological field tests.

• Aquifer heterogeneity well validated with external data (e.g. eochemical, historical...) not used during the model calibration.

• Benzene modelisations reproduce faithfully observed back and forward plume movements, as well as the absence of benzene near the river.

• Reactive modeling to study the effect of river water flowing into the aquifer and future scenarios for inorganic pollution in case of changing geochemical conditions.

Acknowledgements

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Thanks for your attention!!