

Emerging Groundwater Pollution Issues

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University of Tübingen

Groundwater Forum Conference 2009



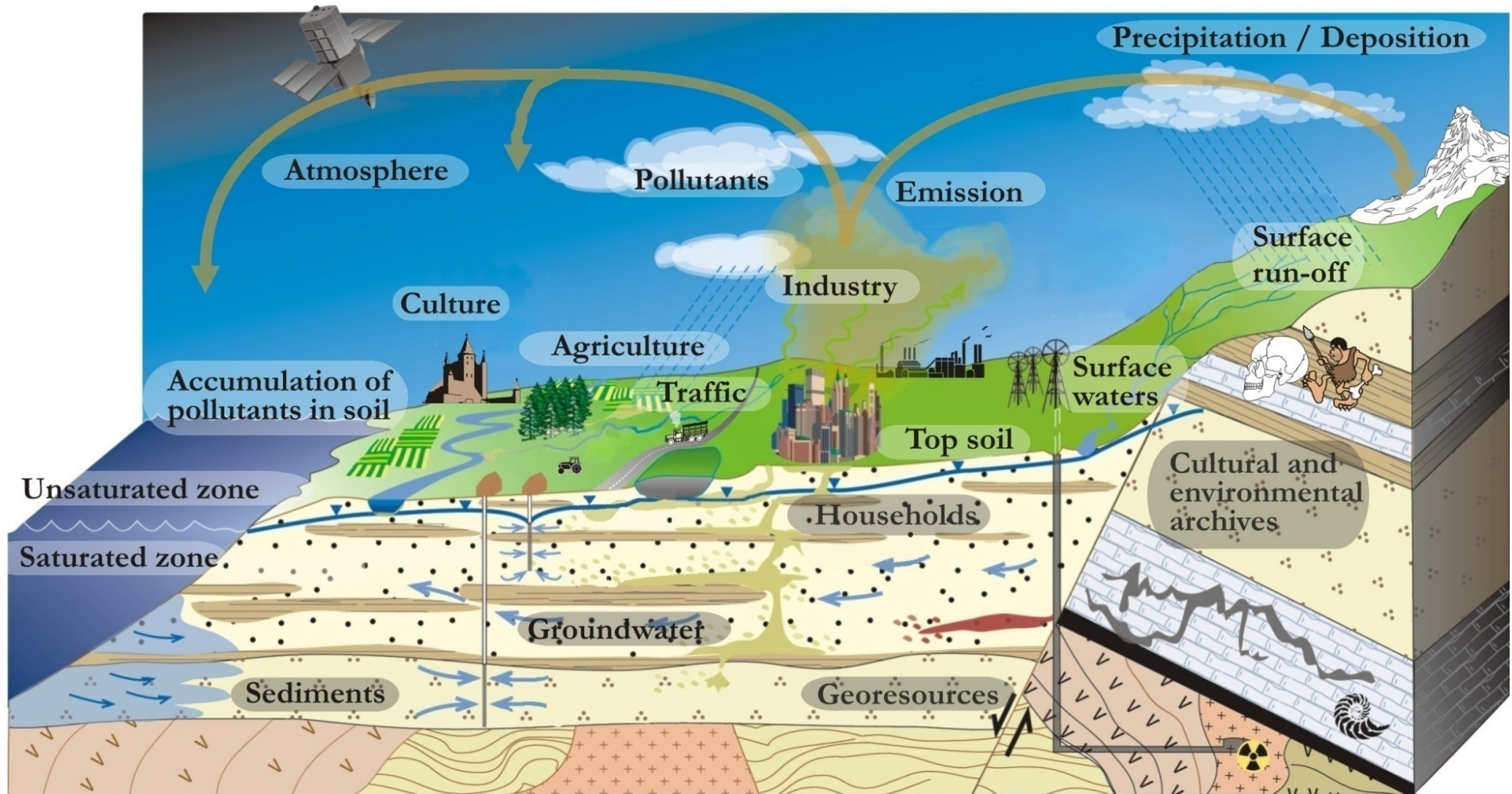
Integrated modelling of the river-sediment-groundwater-soil-system: Advanced tools for the management of catchment areas and river basins in the context of global change



45 partners
12 EU + 3 other countries
EU-contribution: 13 M€
Total: 20 M€
Approx. 12 000 pages of
deliverables
Special issues:
Environmental Pollution
J. Hydrology
Environ. Sci Technol.

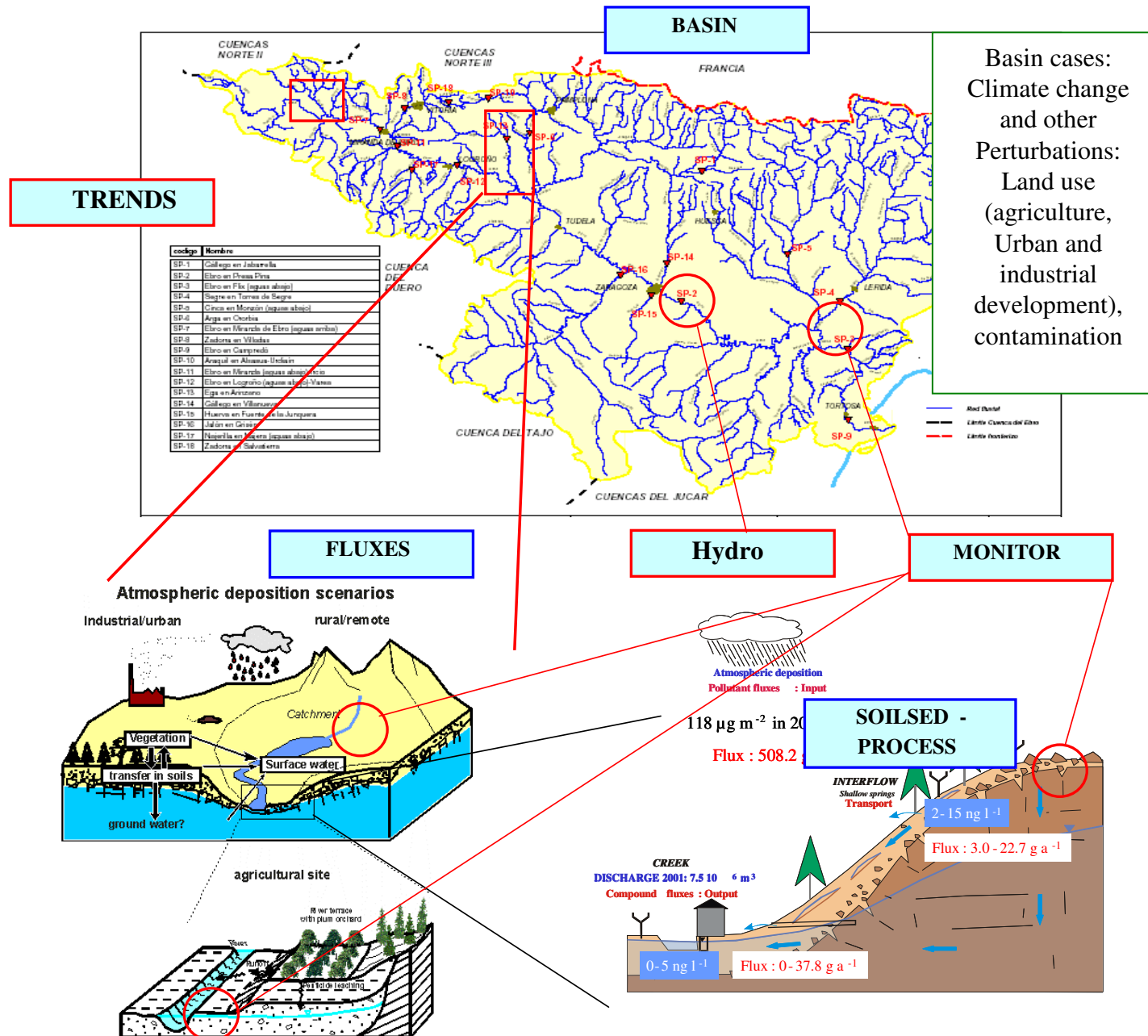


AquaTerra → Goal



➡ towards a better understanding of fate and transport of pollutants in the environment for a prediction of future trends

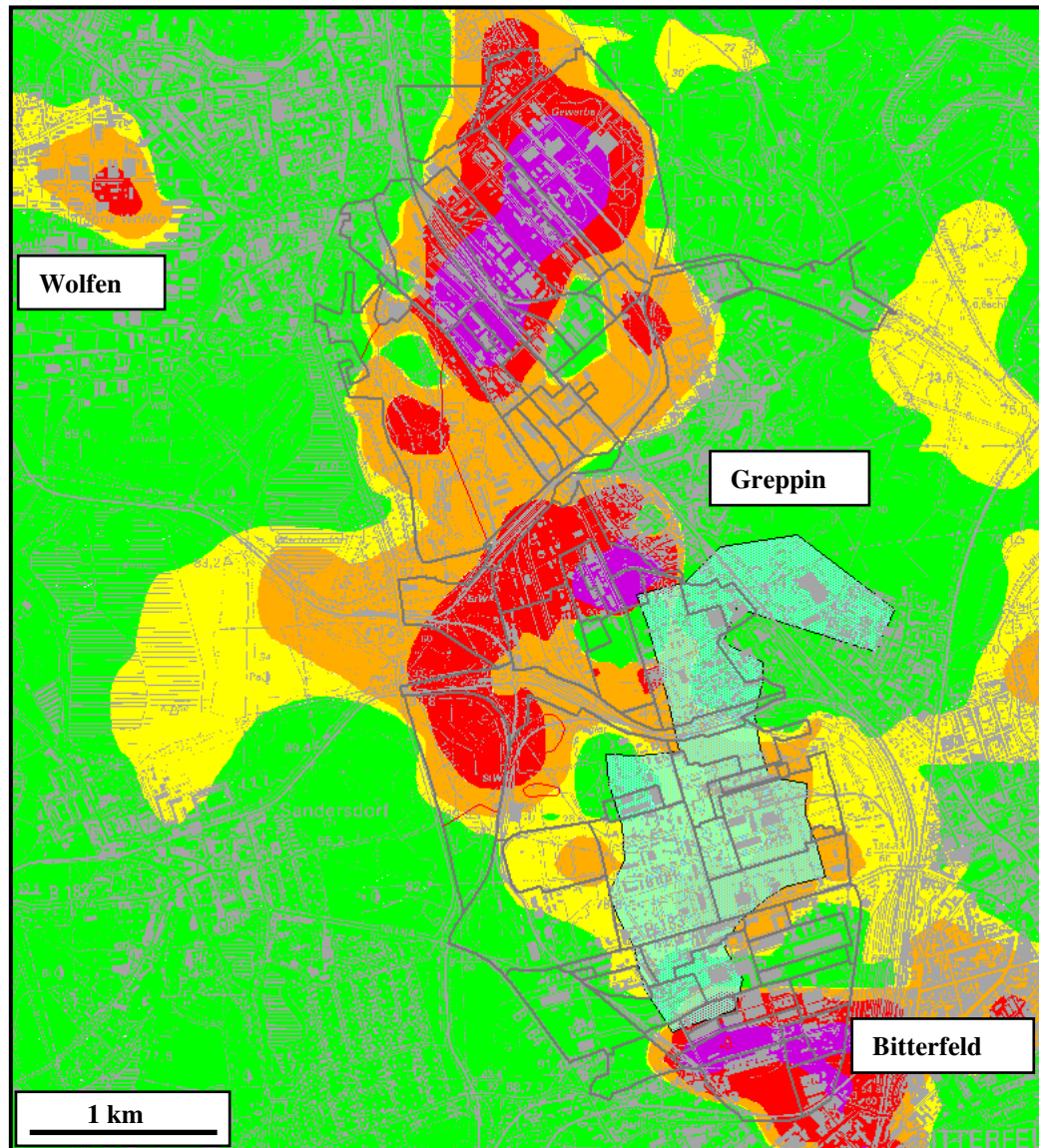
Understanding of the soil – groundwater system at field scale



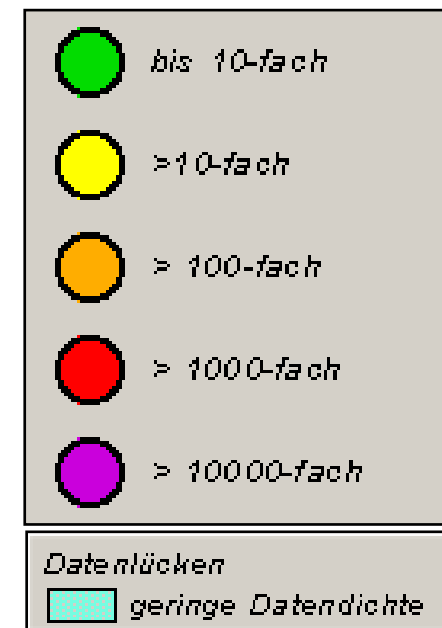
Scales: Mega Sites



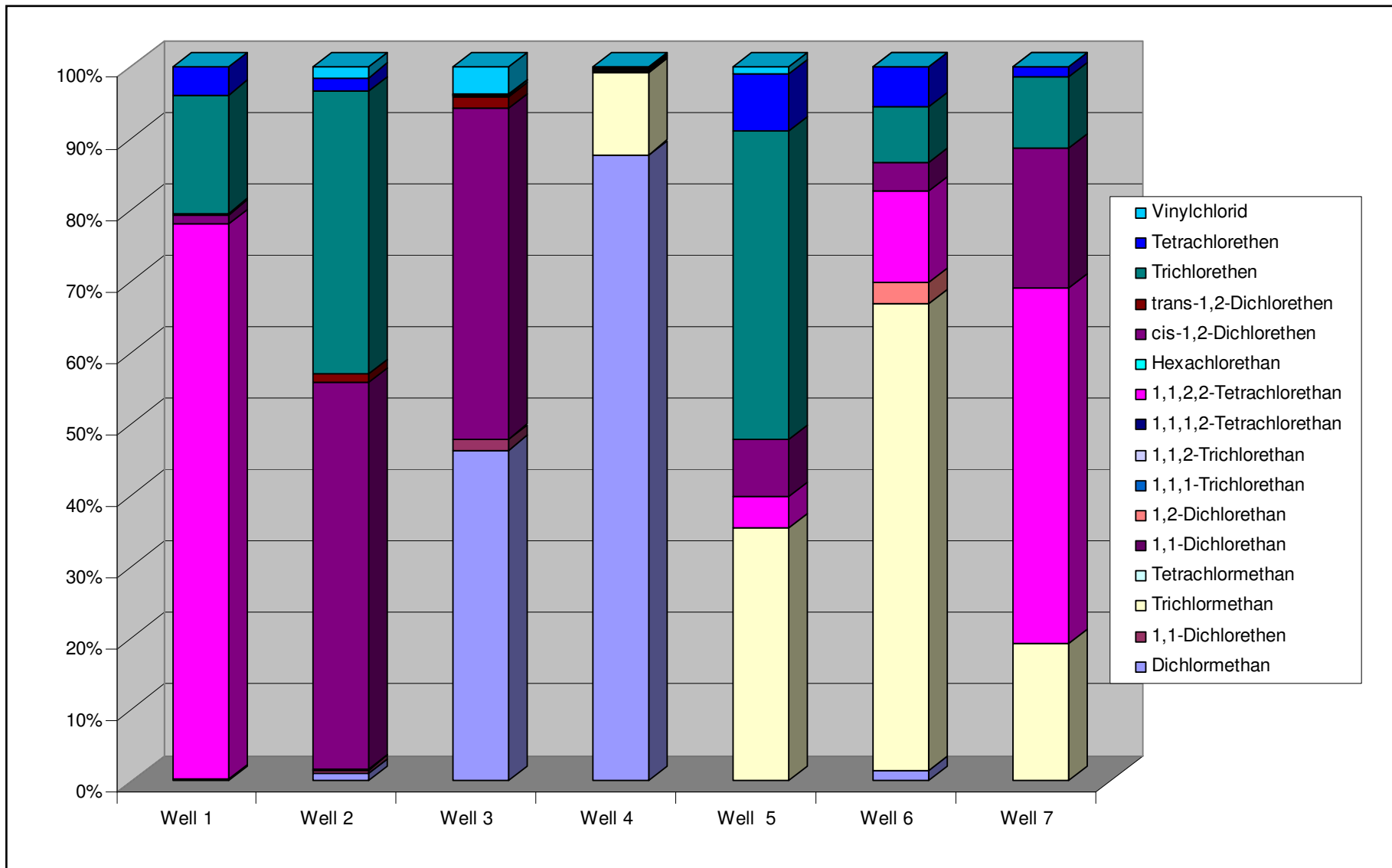
Ground water contamination (2002) – Quarternary Aquifer



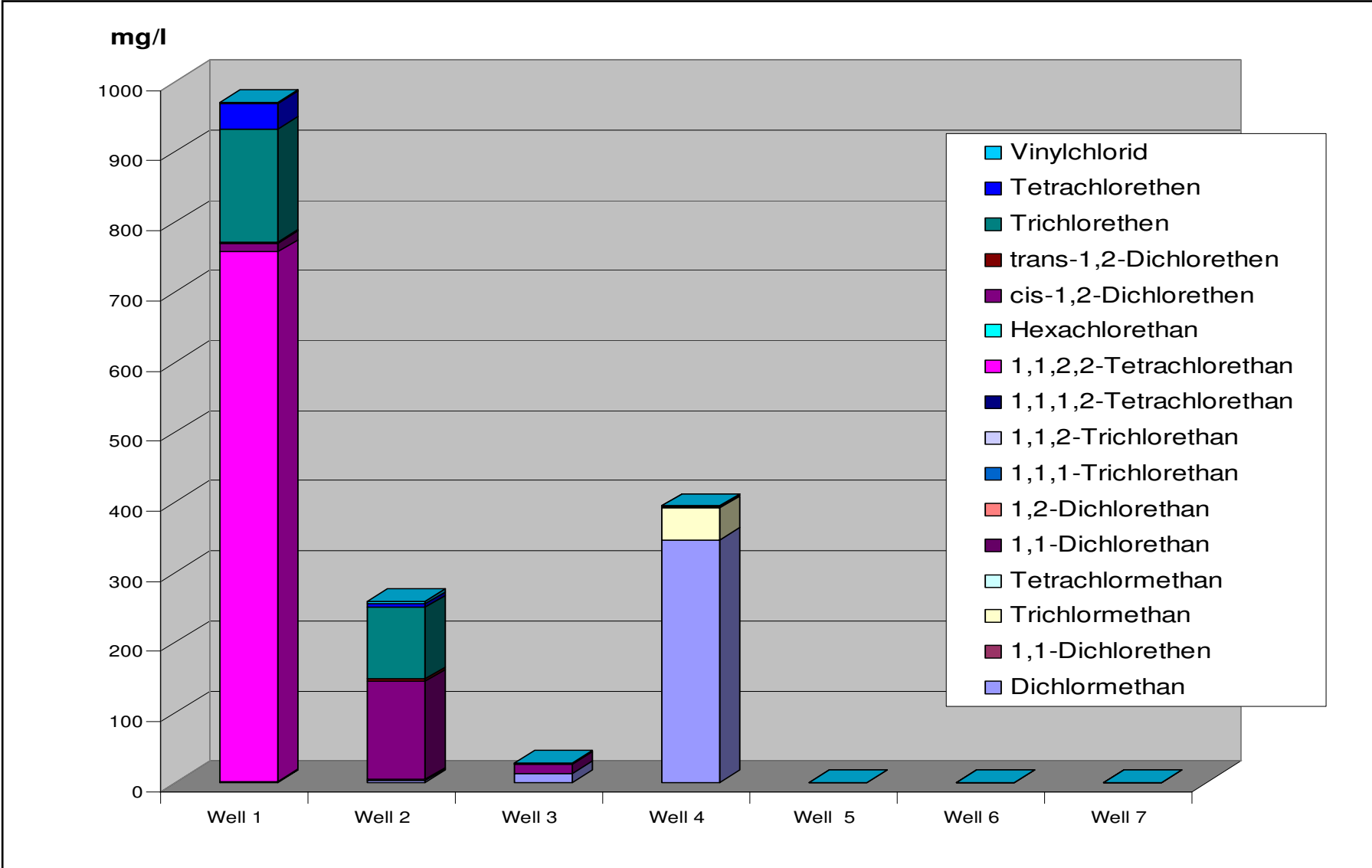
Exceedance of the insignificance threshold in the tertiary aquifer



Observation wells north of Bitterfeld – Cont. distribution



Observation wells north of Bitterfeld – Cont. concentration



Organic contaminants in groundwater - Bitterfeld/North

Group	Compound	µg/l	Group	Compound	µg/l
Anilines	Aniline	23	CI-Phenols	Monochlorophenols	440
	Methylbenzamine	15		2,4-Dichlorophenol	9
	Chloroanilines	1181		2,4,6-Trichlorophenol	9
	Chloro-N-methylbenzenamine	19		Pentachlorophenol	17
	Dichlorobenzenamine	415		4-Chloro-3-Methylphenol	68
BTEX	Benzene	26054	Phenols	Phenol	93
	Toluene	331		Methylphenols	328
	Ethylbenzene	19		Dimethylphenols	17
	Xylenes	147		Ethylphenol	16
				Diethylphenol	29
CVOC	Dichloromethane	111		Ethylmethylphenols	42
	Trichloromethane	4449		Trimethylphenols	12
	trans-1,2-Dichloroethene	25		4-Nitrophenol	168
	cis-1,2-Dichloroethene	69	Pesticides	Trimethylthiophosphat	53
	Trichloroethene	28		HCHs	1
CI-Benzenes	Chlorobenzene	37140		Trithiolan	259
	Chlormethylbenzene	241		Tetrachlorthiophene	66
	Bromochlorobenzene	24		Pentachlorthiocane	19
	2-Chlorotoluene	350		Sulfur	38
	1,3- /1,4-Dichlorobenzene	14073	Others	Bromphenylhydrazine	76
	1,2-Dichlorobenzene	9655		Dimethylphthalate	76
	Dichloromethylbenzene	64		Ethylmandelate	223
	1,2,4 Trichlorobenzene	1010		Benzylbutylphthalate	122
	1,2,3 Trichlorobenzene	43		Bromobenzene	58
	1,2,4,5 Tetrachlorobenzene	42		Cyclohexane	5
	1,2,3,4 Tetrachlorobenzene	344		Naphthalin	25
	Pentachlorobenzene	7		2-Naphthol	43
	Hexachlorobenzene	0,2			

Zero valent iron

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	1,2,3 Trichlorbenzene	43		Benzylbutylphthalate	122
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	Pentachlorobenzene	7		Naphthalin	25
	Hexachlorobenzene	0,2		2-Naphthol	43

Palladium based catalysts

Group	Compound	µg/l	Group	Compound	µg/l
Anilines	Aniline	23	Cl-Phenols	Monochlorophenols	440
	Methylbenzamine	15		2,4-Dichlorophenol	9
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	Pentachlorobenzene	7		Naphthalin	25
	Hexachlorobenzene	0,2		2-Naphthol	43

GAC – granular activated carbon

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	Chloroanilines	1181		2,4,6-Trichlorophenol	9
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Microbial degradation

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	Chloroanilines	1181		2,4,6-Trichlorophenol	9
	Chloro-N-methylbenzamine	17		2,4,6-Trichlorophenol	17
	Dichlorobenzene	68		2,4,6-Trichlorophenol	68
BTEX	Benzene	20034	Phenols	Phenol	93
	Toluene	331		Methylphenols	328
	Ethylbenzene	17		Ethylphenols	16
CVOC	Xylene	29	Pesticides	Trimethylthiophosphat	53
	Dichlorobenzene	42		HCHs	1
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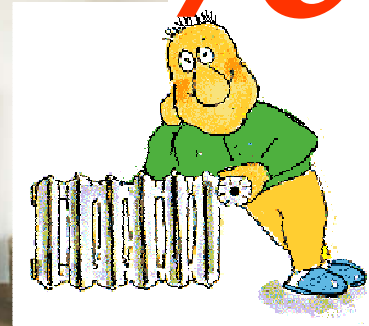
Diffuse pollution



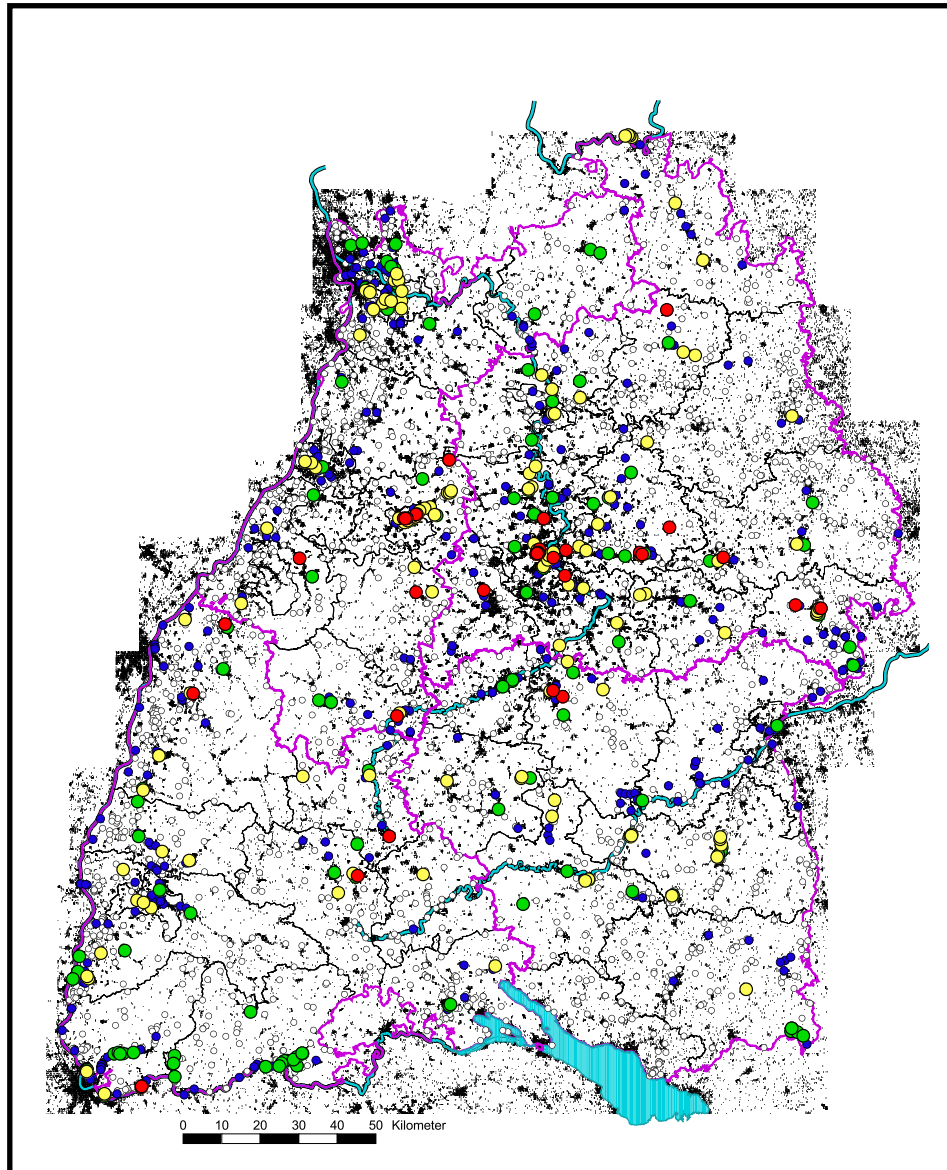
30 %



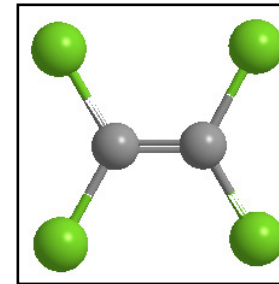
70 %



PCE in groundwater



Tetrachloroethene (PCE)



Sampling campaign 1998

Conc. in mg/l

n.d.

• < 0.0010

• 0.0011 – 0.0050

• 0.0051- 0.1000

• > 0.1000

LFU -
Baden Württemberg

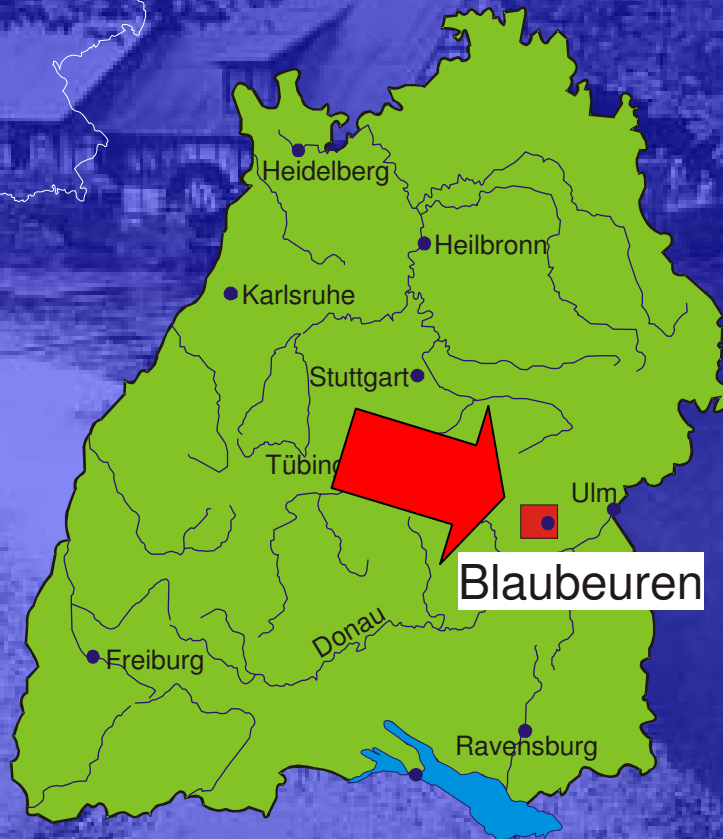
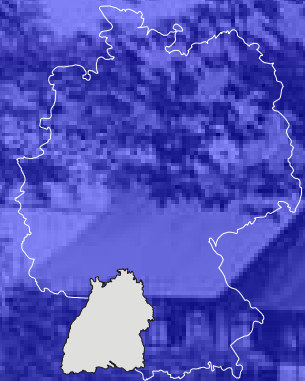


Water Framework Directive

List of priority substances in the field of water policy

Priority hazardous substances	... under investigation	... not considered as bioaccumulative, toxic etc.
Brominated diphenyl ethers (penta) Cadmium Mercury C₁₀-C₁₃ Chloroalkanes Hexachlorobenzene Hexachlorocyclohexane Tributhyltin Hexachlorobutadiene Nonylphenols <u>PAH</u> Pentachlorobenzene	Anthracene Atrazine Chlorpyrifos Di(2-ethylhexyl)phthalate (DEHP) Endosulfan Lead Naphthalene Octylphenols Pentachlorophenol Trichlorobenzenes Trifuralin	Alachlor Benzene Chlorfenvinphos Dichloromethane 1,2-Dichloroethane Diuron Isoproturon Nickel Simazine Trichloromethane
Subject to phase-out or under consideration for phase-out (or severe restriction) on the international level	Shows properties similar to those identified as "Priority Hazardous" (group 1) Subject to a review for identification as possible priority hazardous substances by 31 December 2003.	Do not fulfil the criteria for being "toxic, persistent and liable to bioaccumulate" Classified as dangerous Subject to emission controls and quality standards

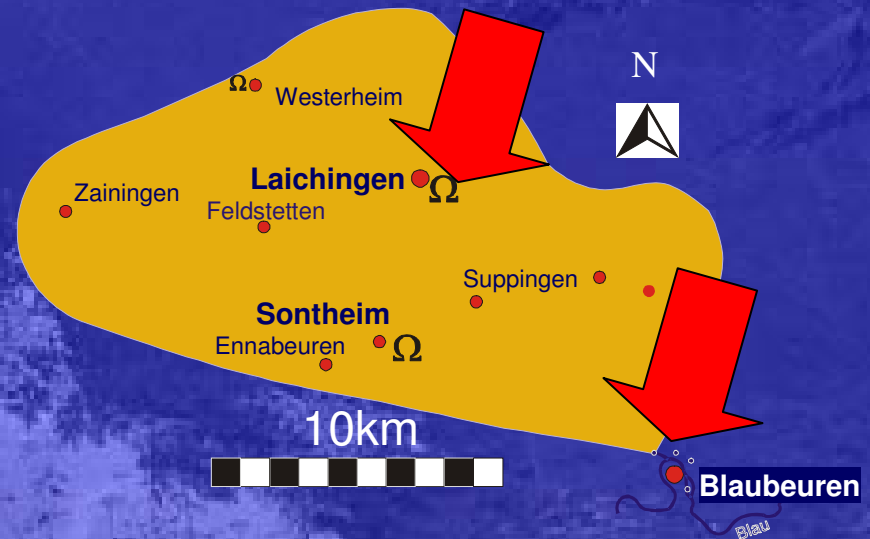
Baden-Württemberg



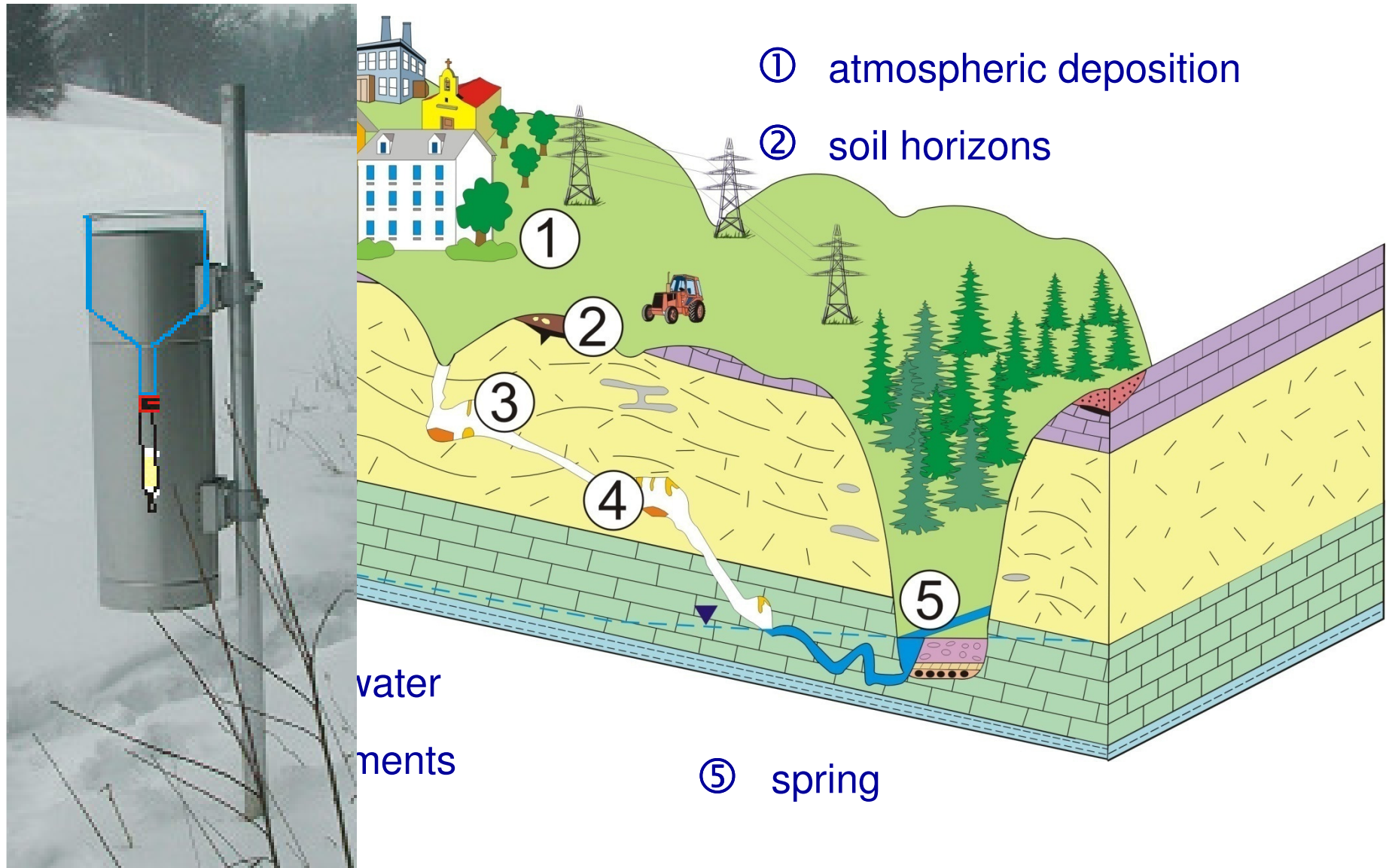
Blautopf

Blautopf Catchment

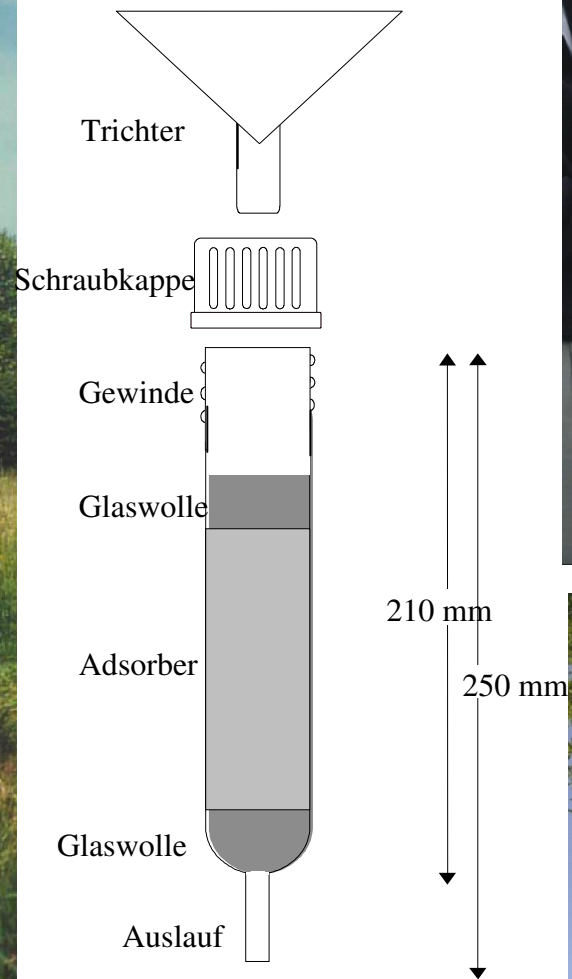
165 km²
~ 50 caves



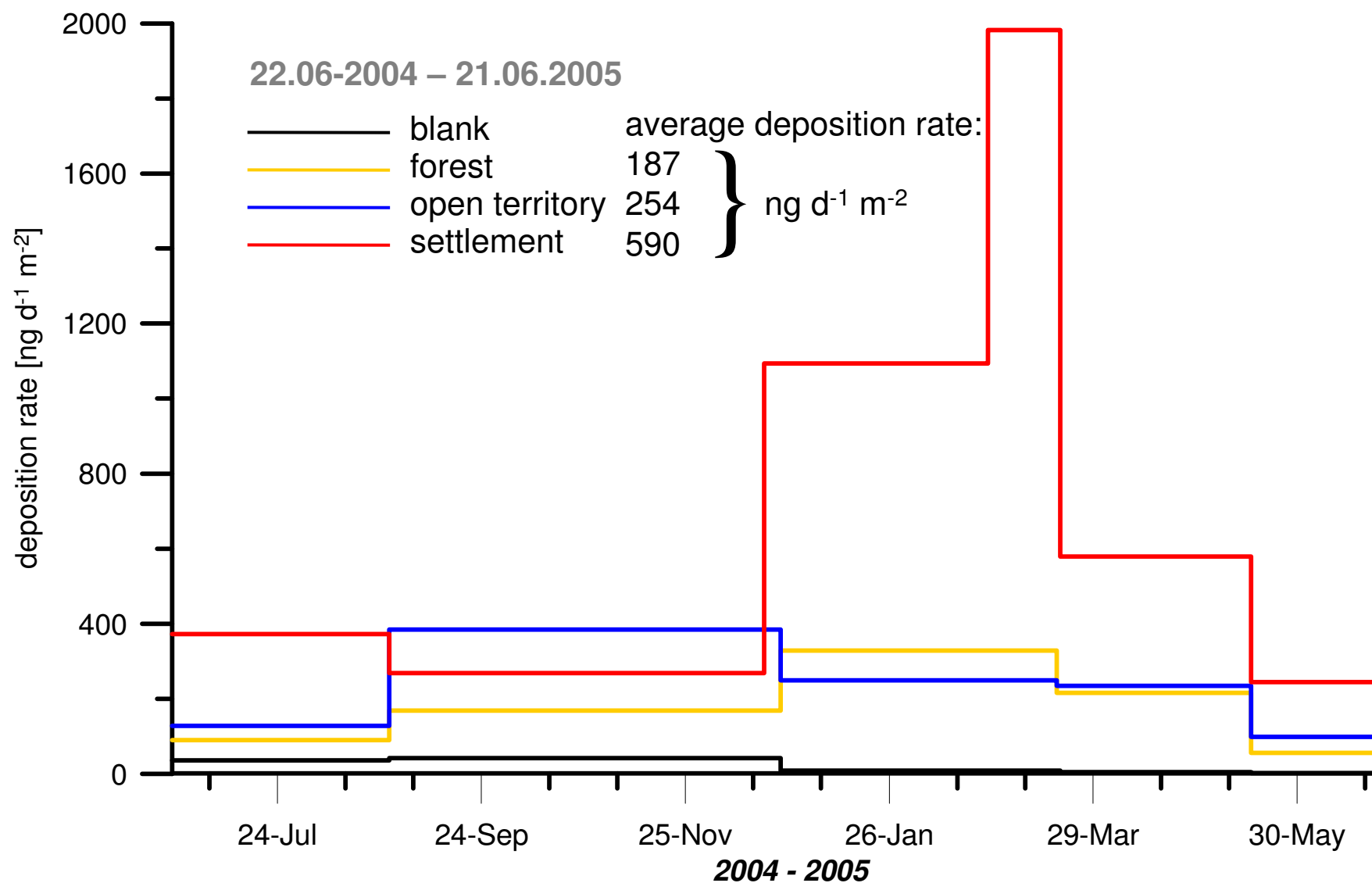
Case Study: Reactive tracers in a karst catchment



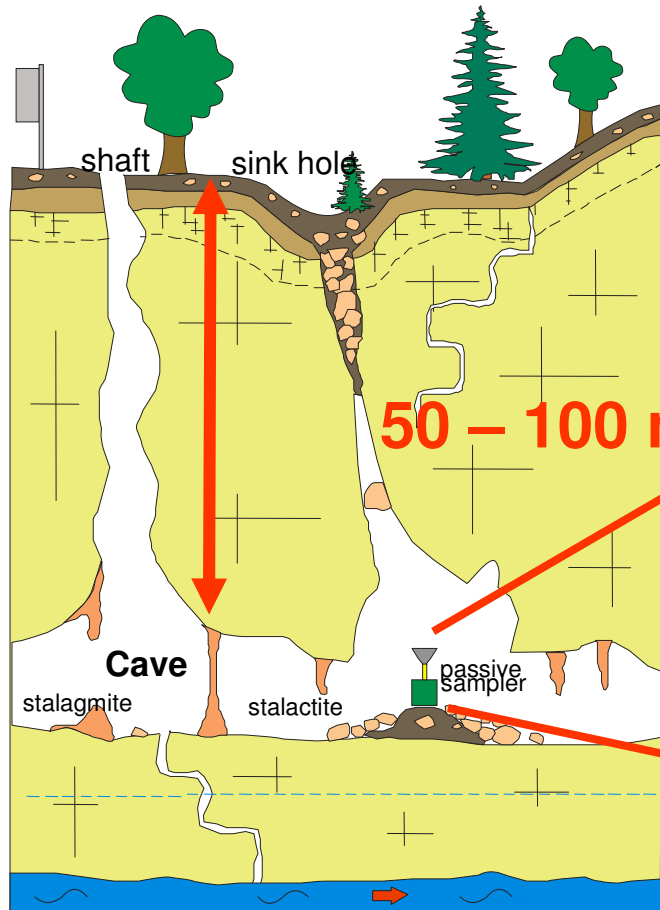
Passive Samplers: Deposition Monitoring of POPs (DIN 19739)



Atmospheric Deposition – Annual Survey



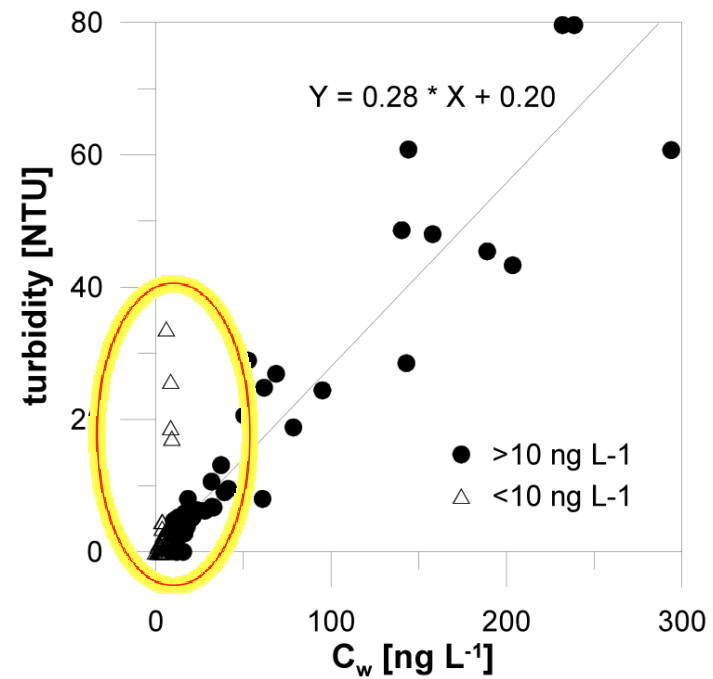
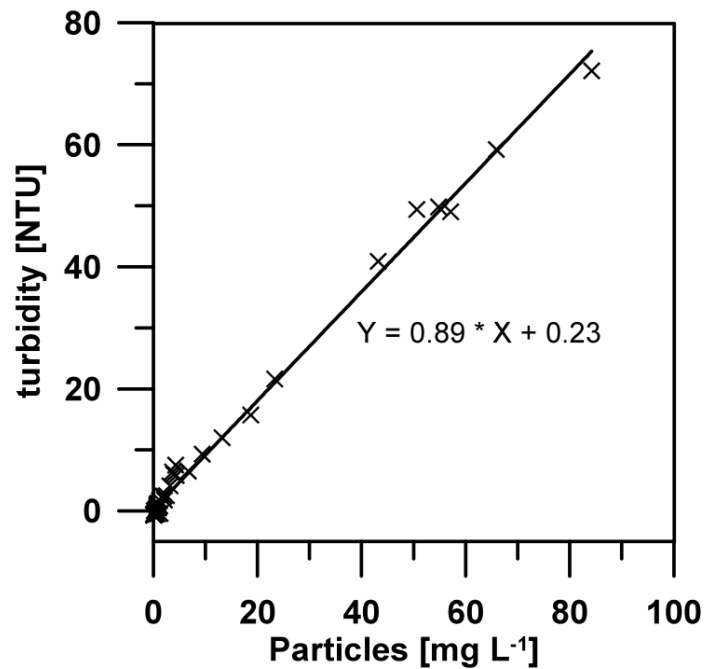
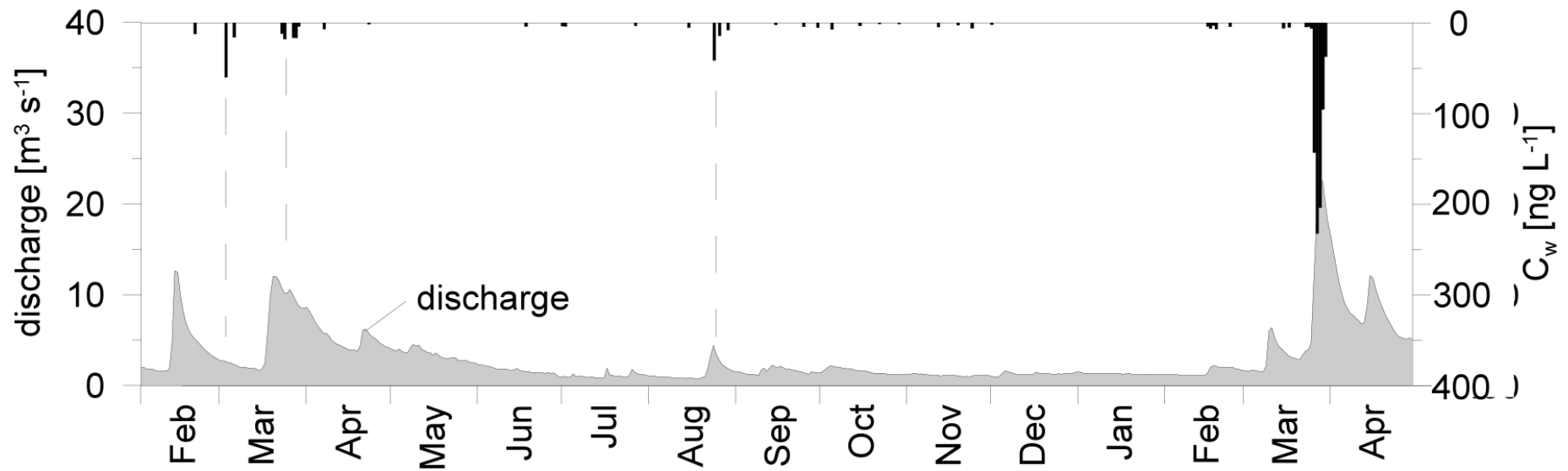
Following seepage water transport



Catchment outlet



Outlet history



Input / outlet mass balance

Input

Atmospheric deposition: $\sim 15 \text{ kg y}^{-1}$

(22.6.04-21.6.05)

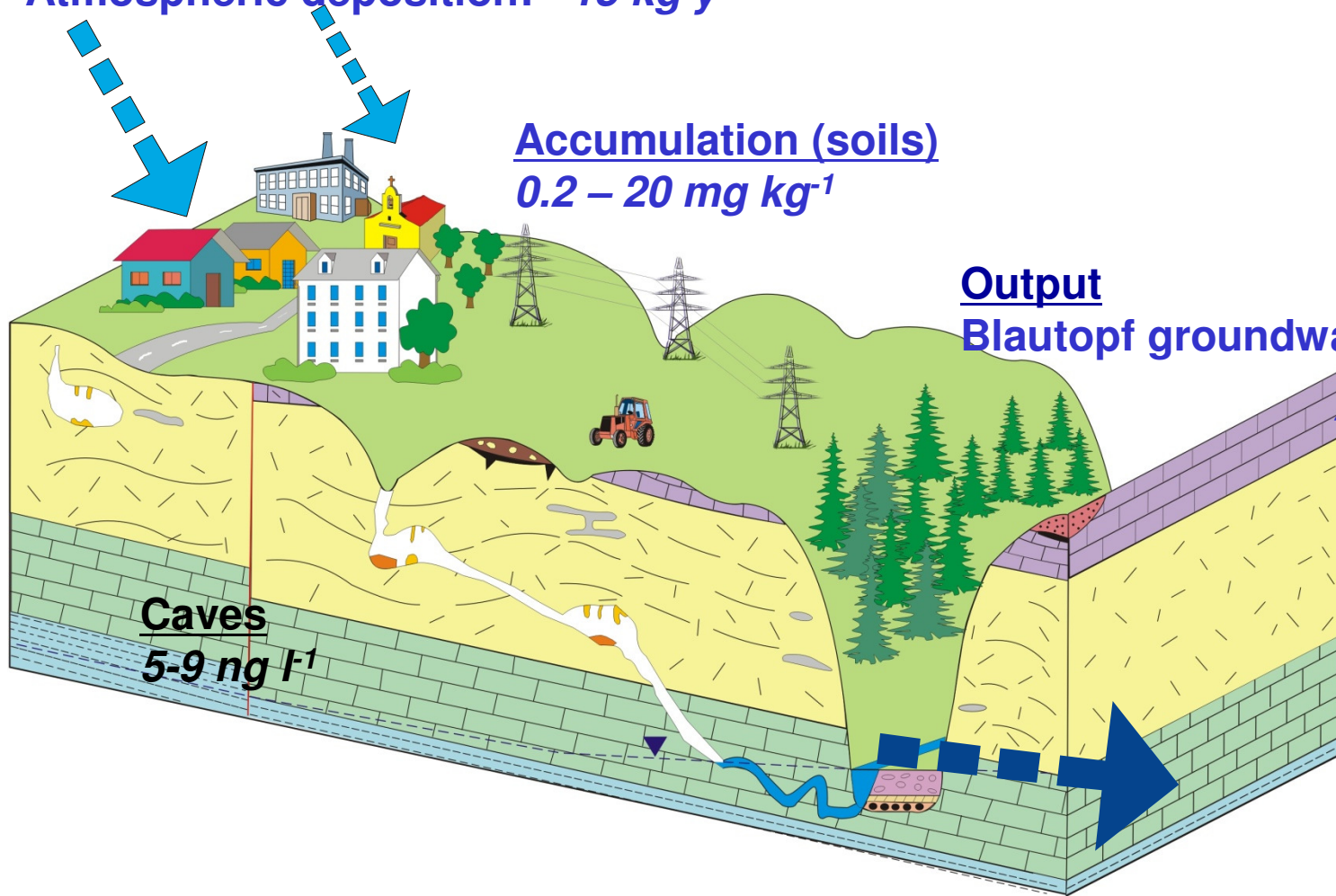
Accumulation (soils)
 $0.2 - 20 \text{ mg kg}^{-1}$

Output

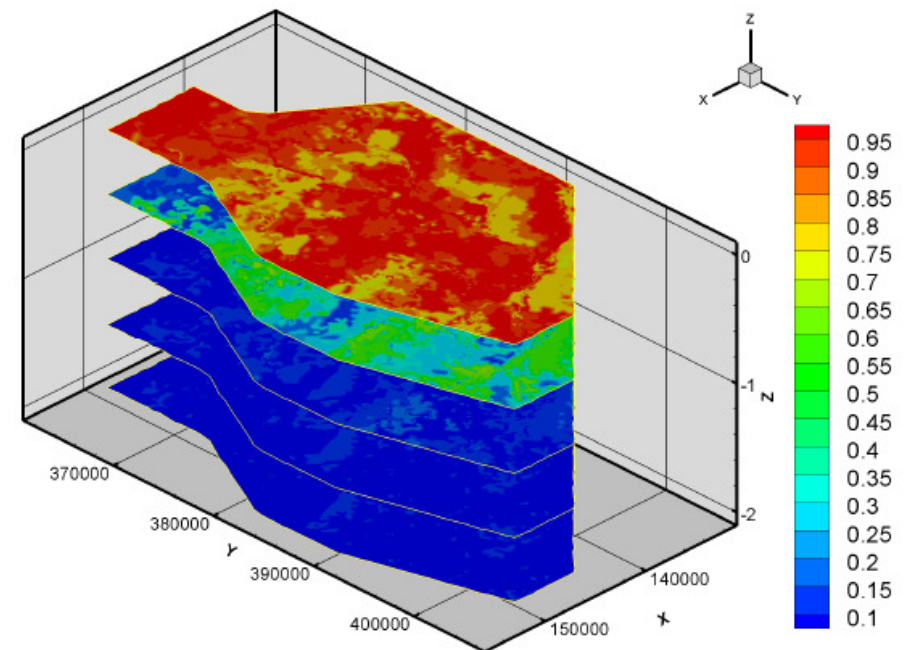
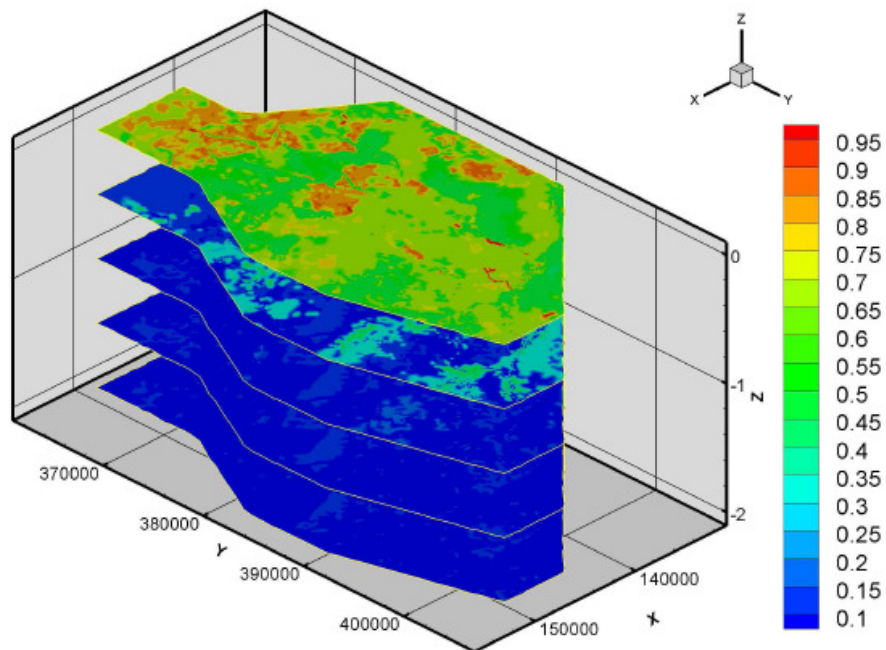
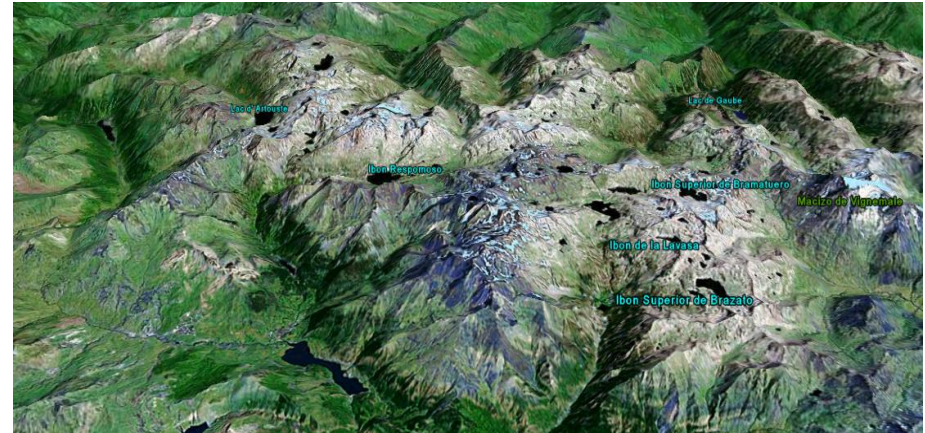
Blautopf groundwater:

$\sim 0.452 \text{ kg y}^{-1}$

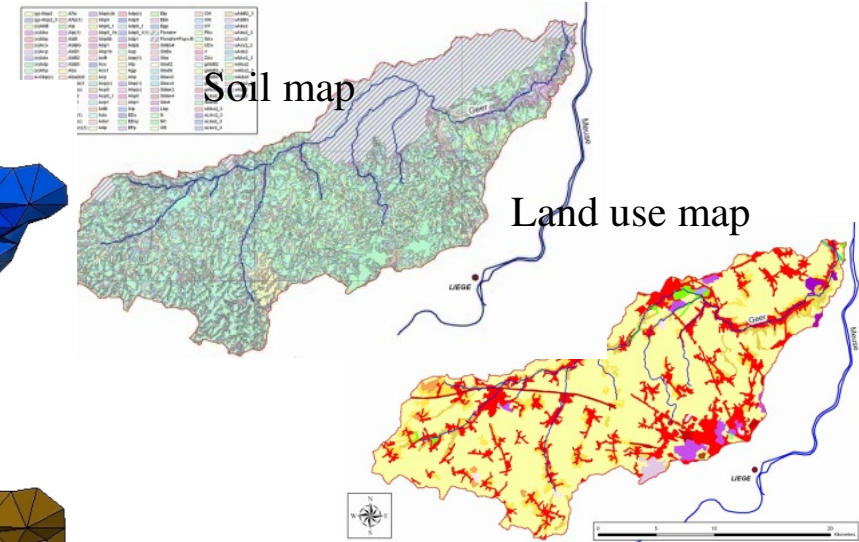
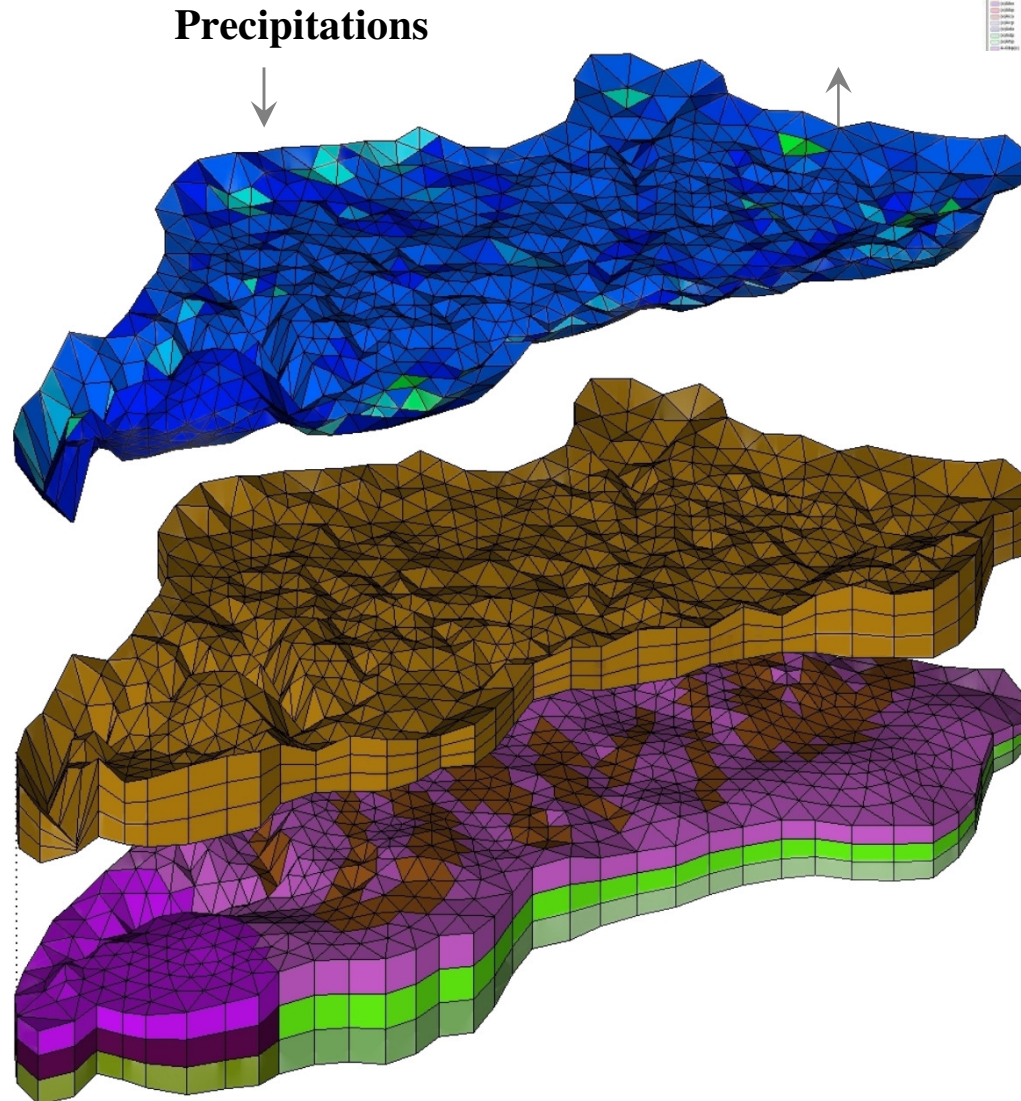
$\sim 3 \%$



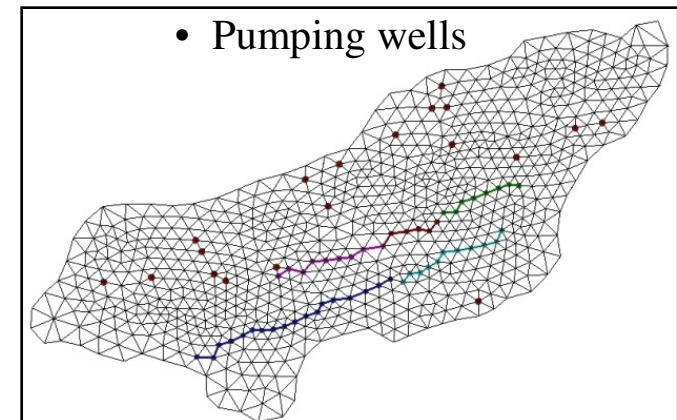
Models for catchment: surface runoff, unsaturated zone, groundwater coupled



Geer basin



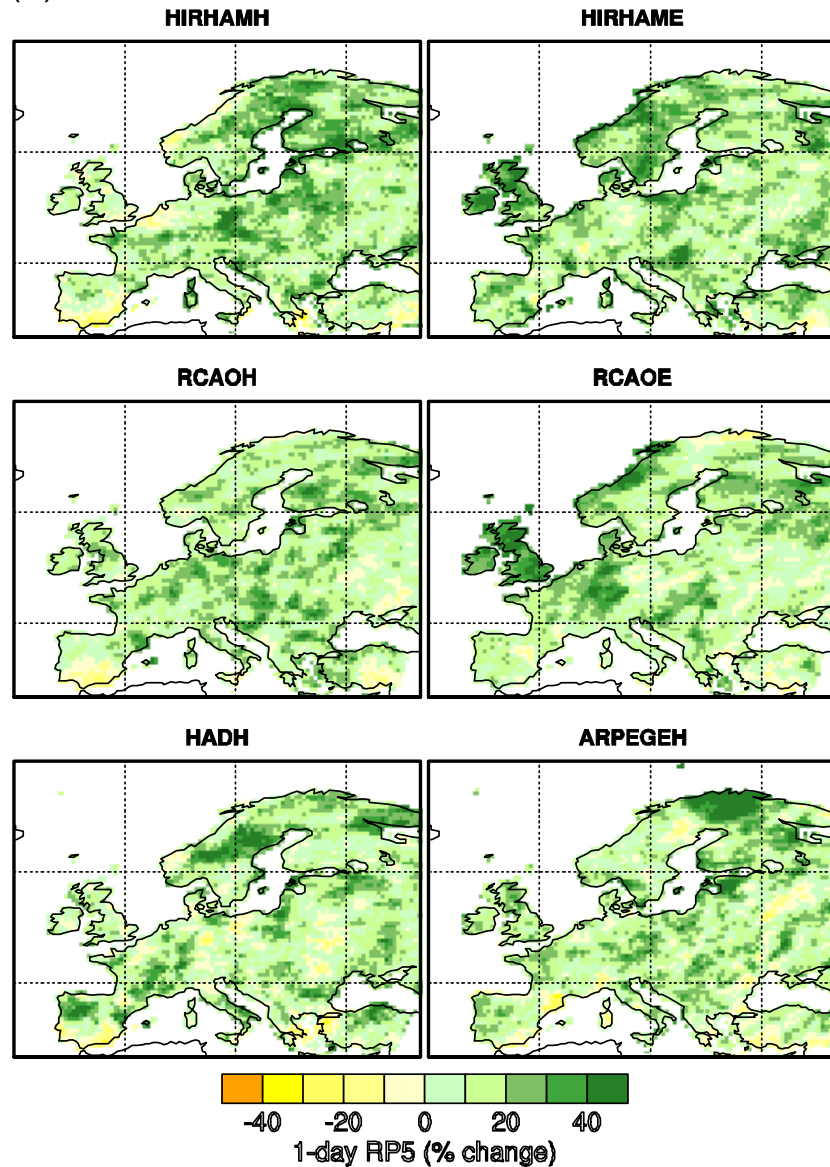
- Saturated - unsaturated hydraulic properties
- Draining galleries



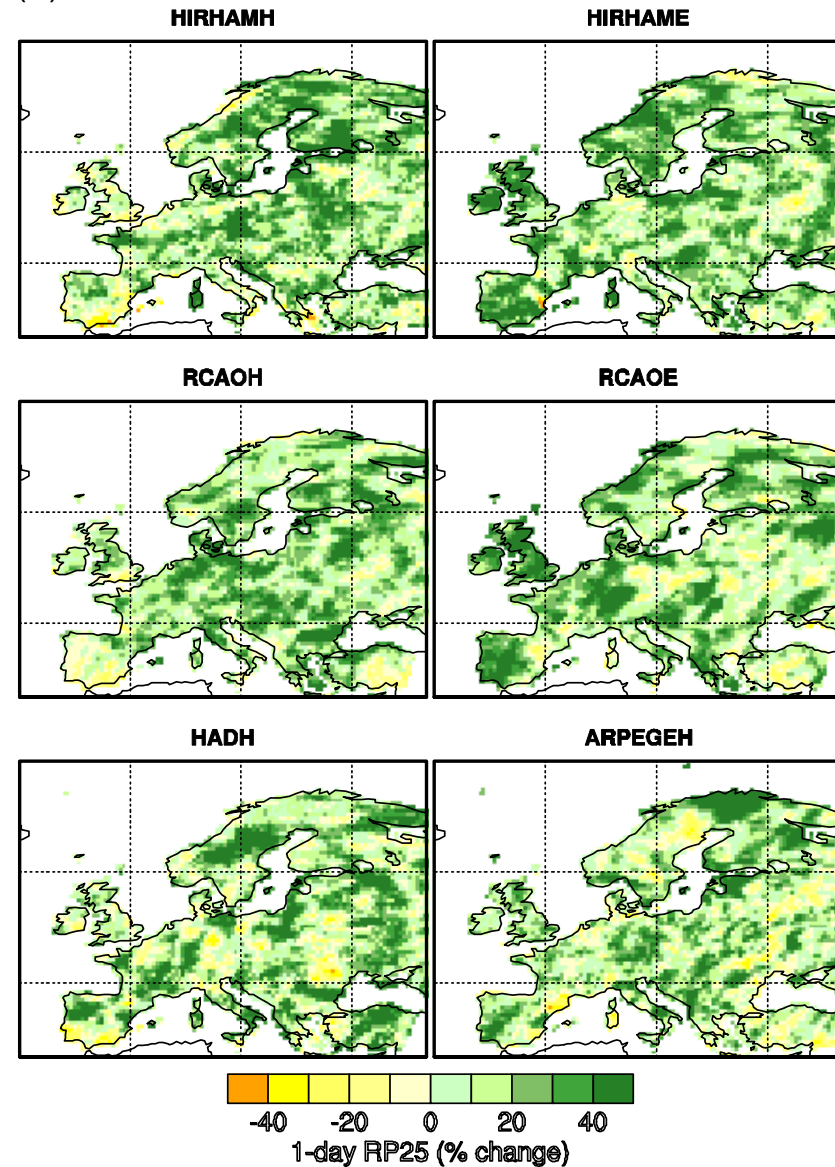
Future Scenarios: Climate Change



(a)



(b)



Application of Climate Change Scenarios

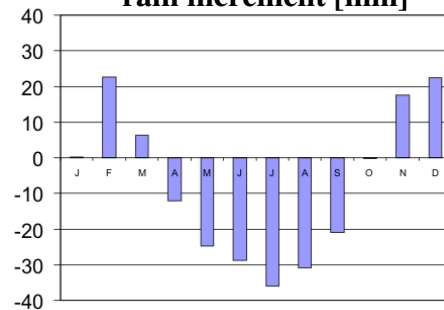


First results of climate change scenarios (from Newcastle University – Hydro WP)

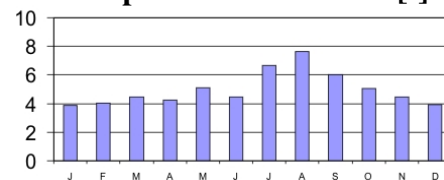
- **6 climatic scenarios :**
HS1 ecscA2 adhfa
HCA2 MPIA2 DE6
- **time interval :** 2010 - 2100
(2010-2040, 2040-2070, 2070-2100)

SCENARIO ecscA2 2070 -2100

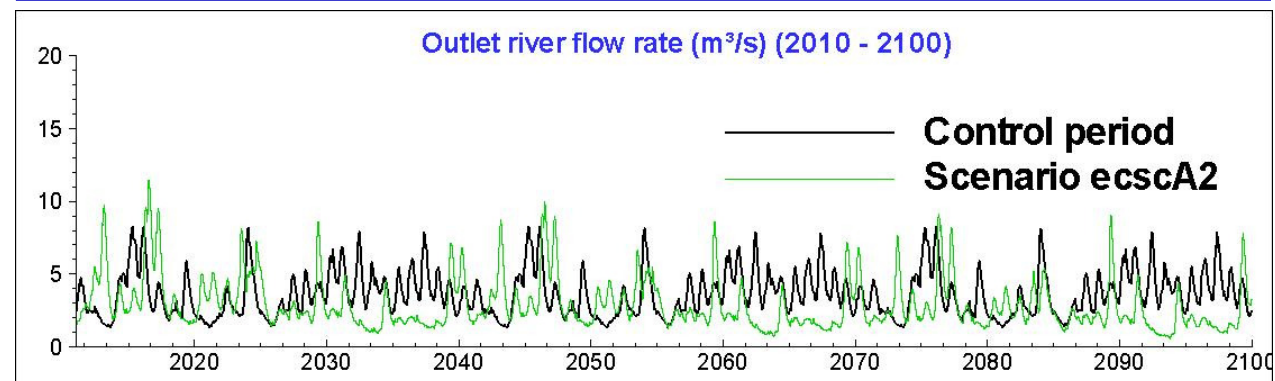
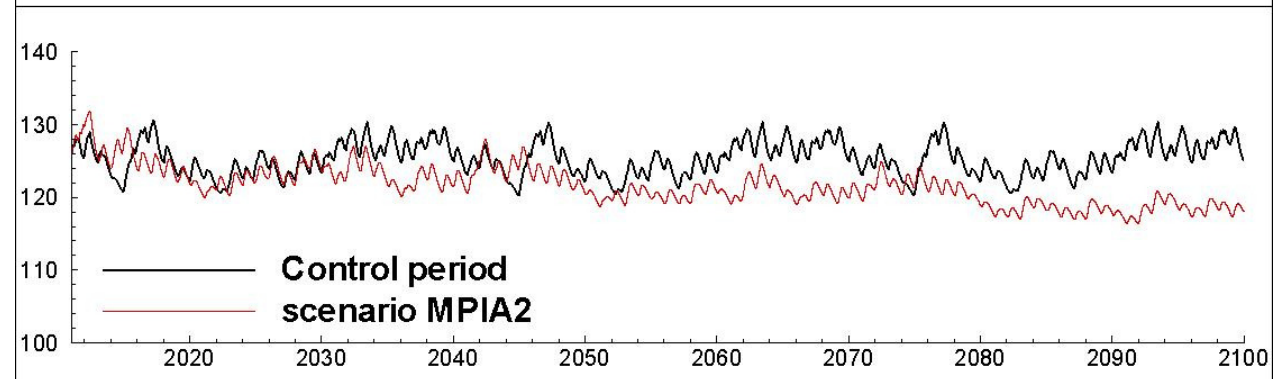
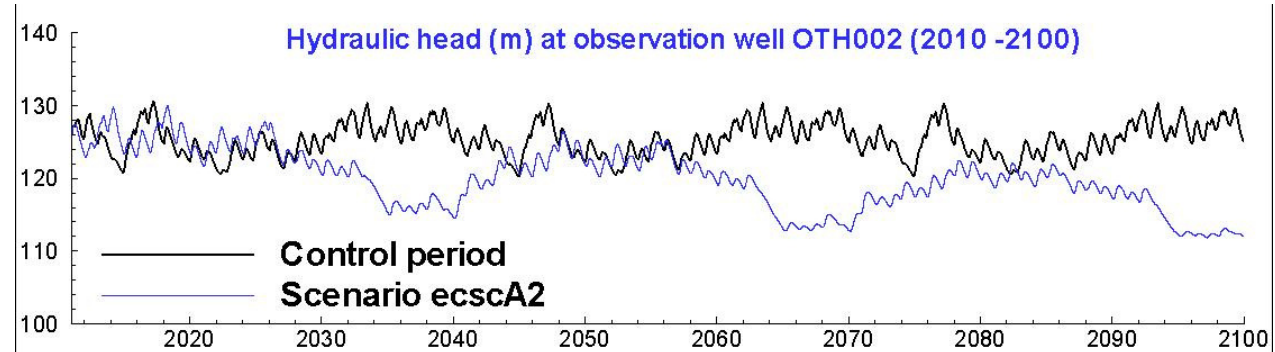
Waremmé station rain increment [mm]



temperature increment [-]



Depending on the scenario,
→ decrease in water level
between 5m and 12m in 2100
→ longer and stronger 'low
water discharge' periods



Lessons learned:

- Diffuse contaminations are quite stable (low concentrations, strong sorption in soils, large scales – groundwater bodies)
- Everything is (nearly) everywhere (cross-compartment transport, global dispersion, etc.)
 - Concentrations are low – but increasing trends in soils
 - Comprehensive monitoring of catchments is required (“more focus – less fragmentation”)

Time-integrated passive sampling for monitoring o.k., time resolved monitoring still needed for process understanding

- Integration is difficult (disciplines, tools, outreach, etc.)

Needed/missing:

- Input/output of mass balances at the catchment scale: ⇒ long term monitoring / “sustainable” sites → hydrologic observatories
- Groundwater - surface water - soil - plant - atmosphere interactions / urban influence
- New modeling approaches for reactive transport at catchment scale

<http://www.uni-tuebingen.de/geo/zag/grathwohl/>

<http://www.eu-aquaterre.de>

<http://www.uni-tuebingen.de/gracos/>

<http://www.uni-tuebingen.de/sowa/>