COMBINED APPROACHES FOR QUALITY MANAGEMENT OF KARSTIC DRINKING WATER RESOURCES

EVENT SAMPLING AS WORST CASE OUTLOOK

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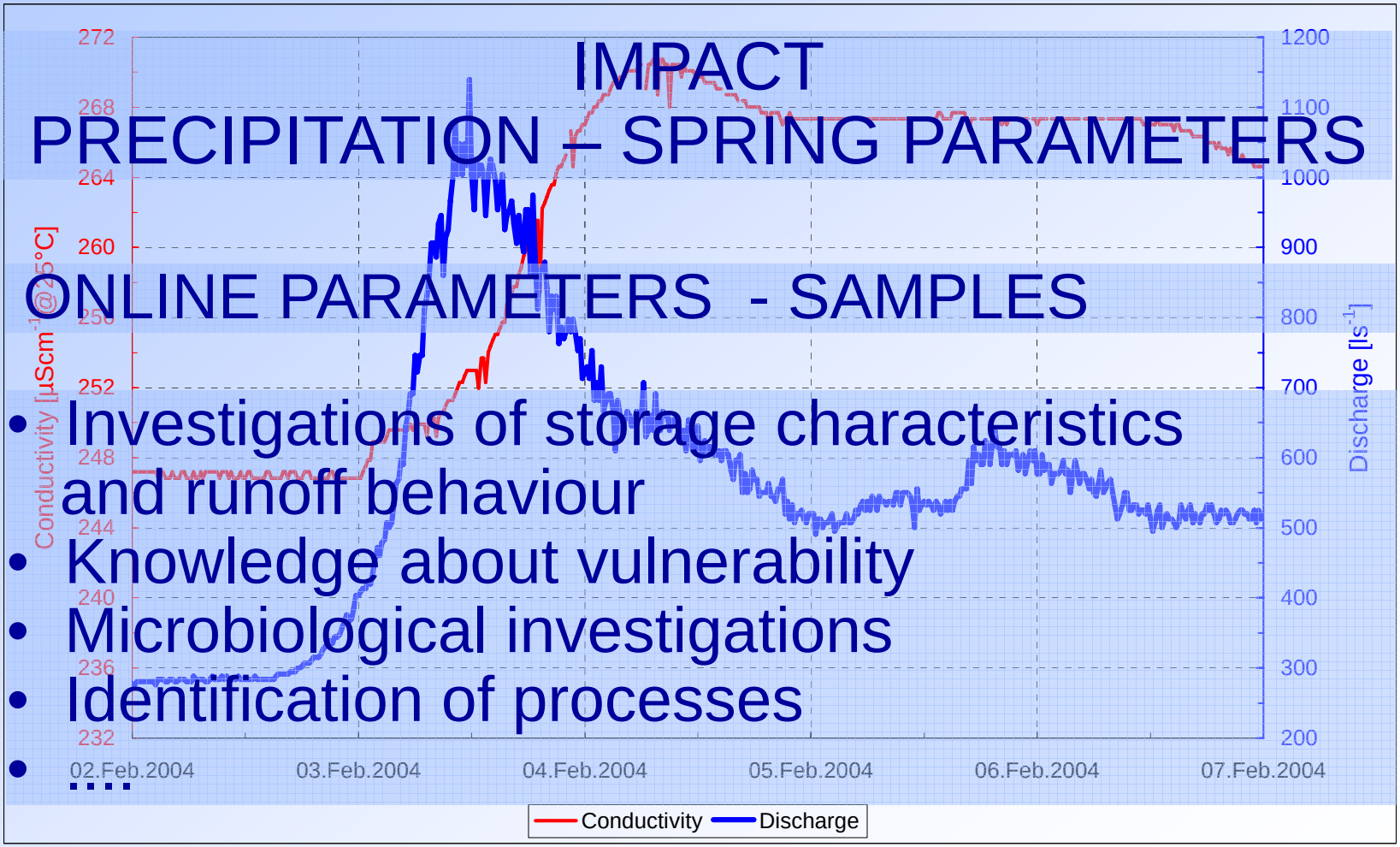
Beograd, June 5, 2014

AGENDA

- What is a hydrological event?
- Something about Karst
- How to sample
- 3 Examples of event-sampling
- Synopsis

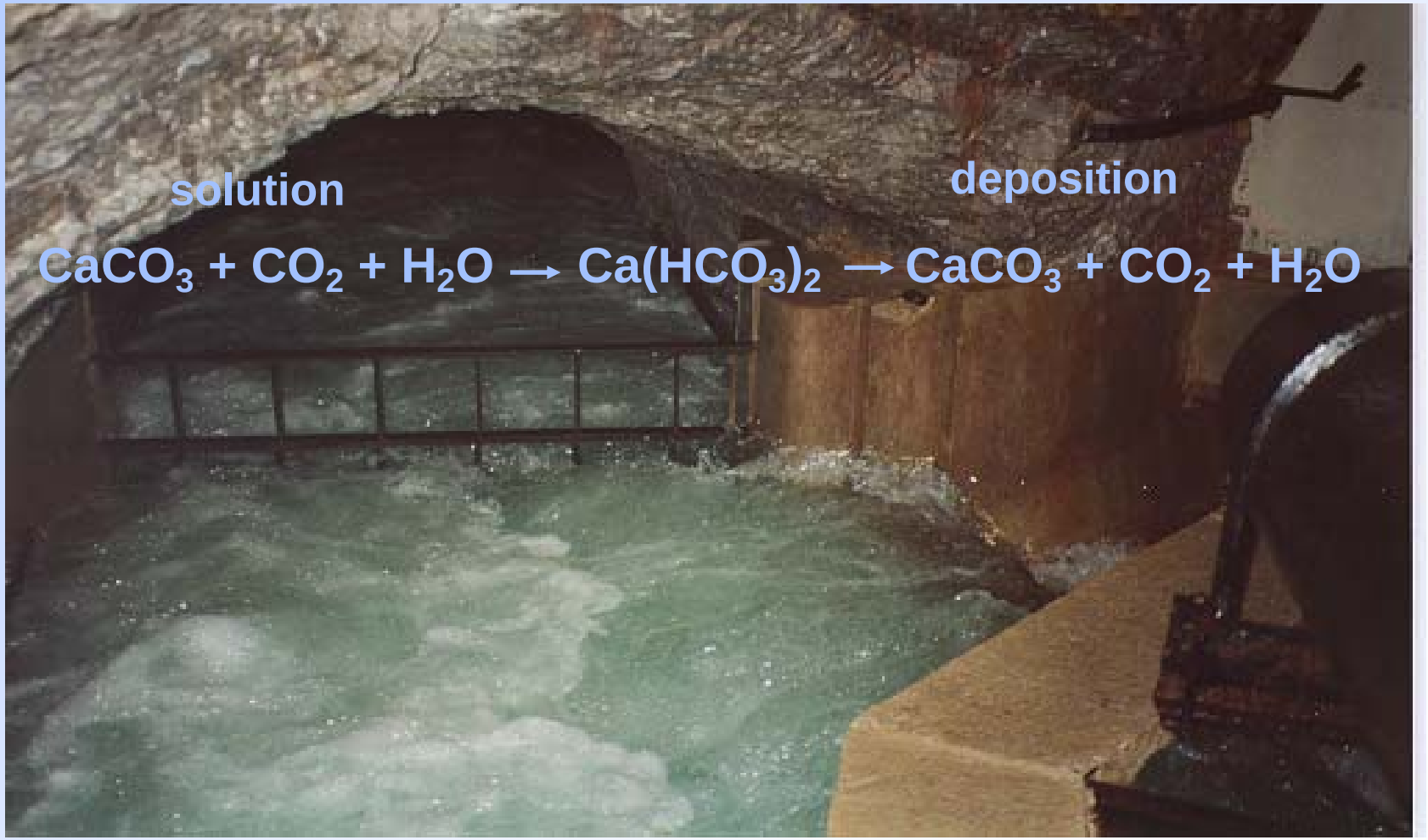
HYDROLOGICAL EVENT



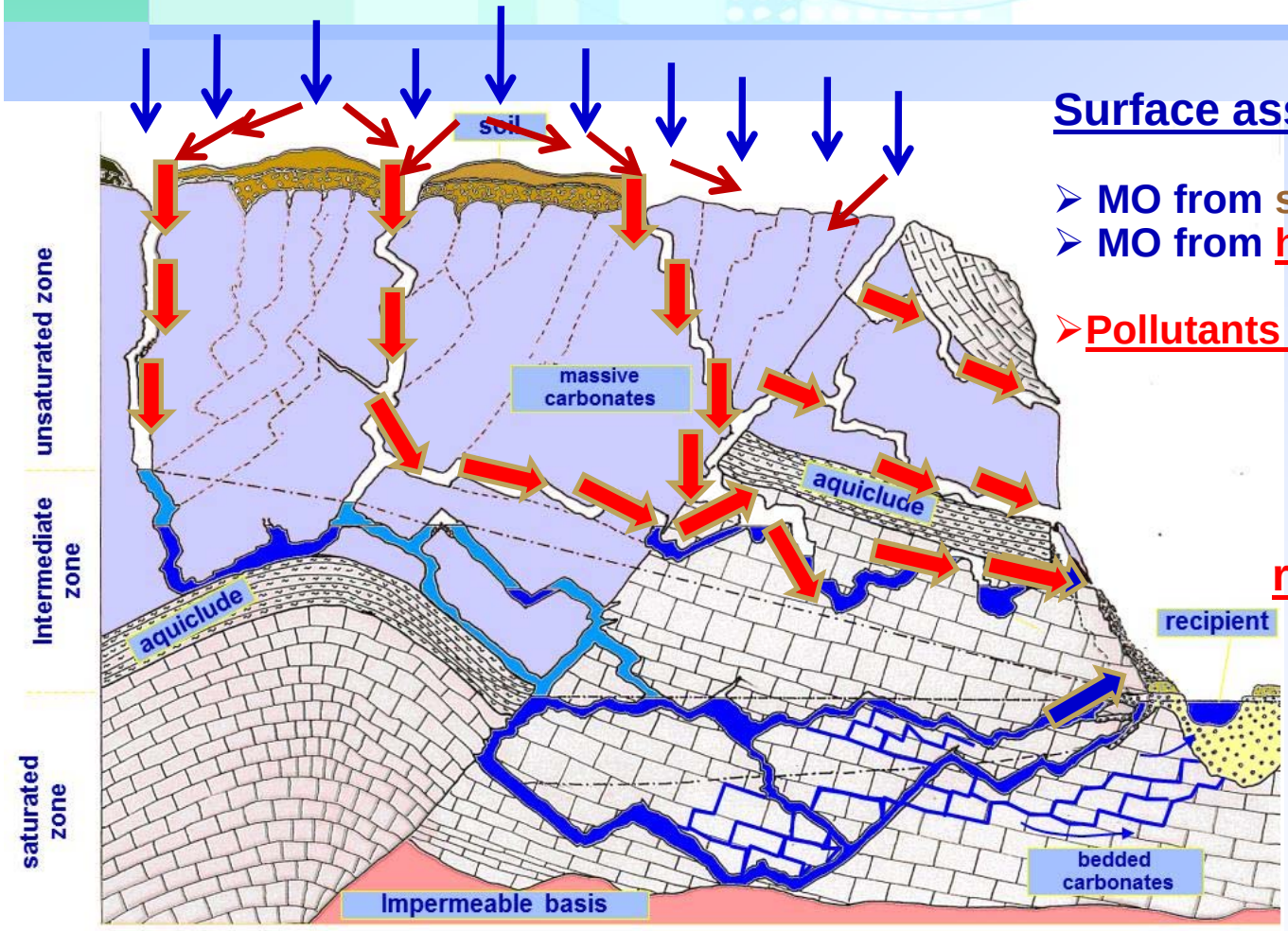
- Investigations of storage characteristics and runoff behaviour
- Knowledge about vulnerability
- Microbiological investigations
- Identification of processes
- ....

Equilibrium

calcium carbonate – carbon dioxide



….a simplified model of spring water quality dynamics



Surface associated microbes

- MO from soil, plants, lakes, brooks
- MO from human & animal faeces

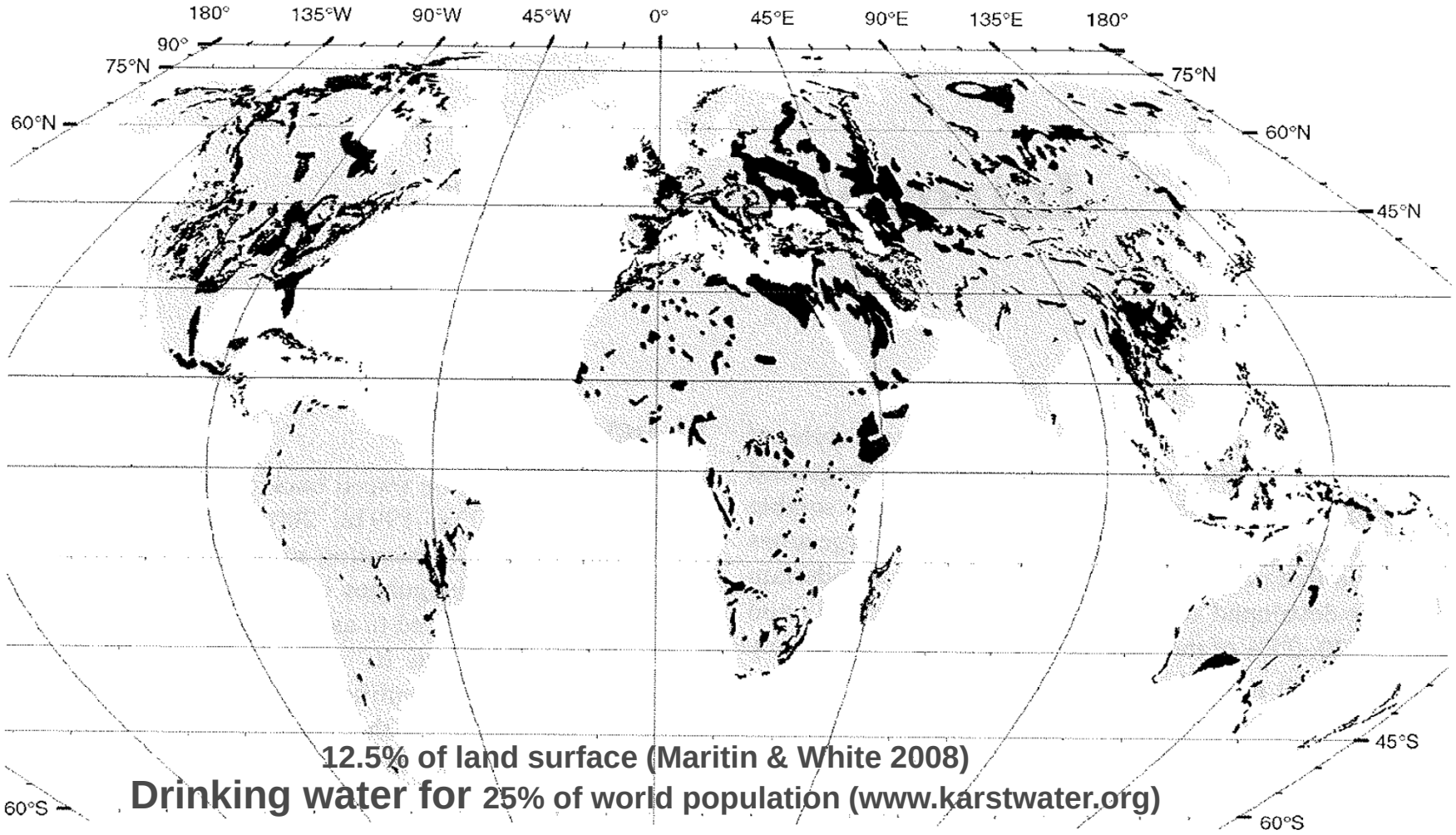
- Pollutants (catchment, airborne)

rapid surface influence

base flow component
good bio-stability &
raw water quality

catchment protection ⟷ optimal water abstraction ⟷ treatment

Distribution of karstifiable rocks

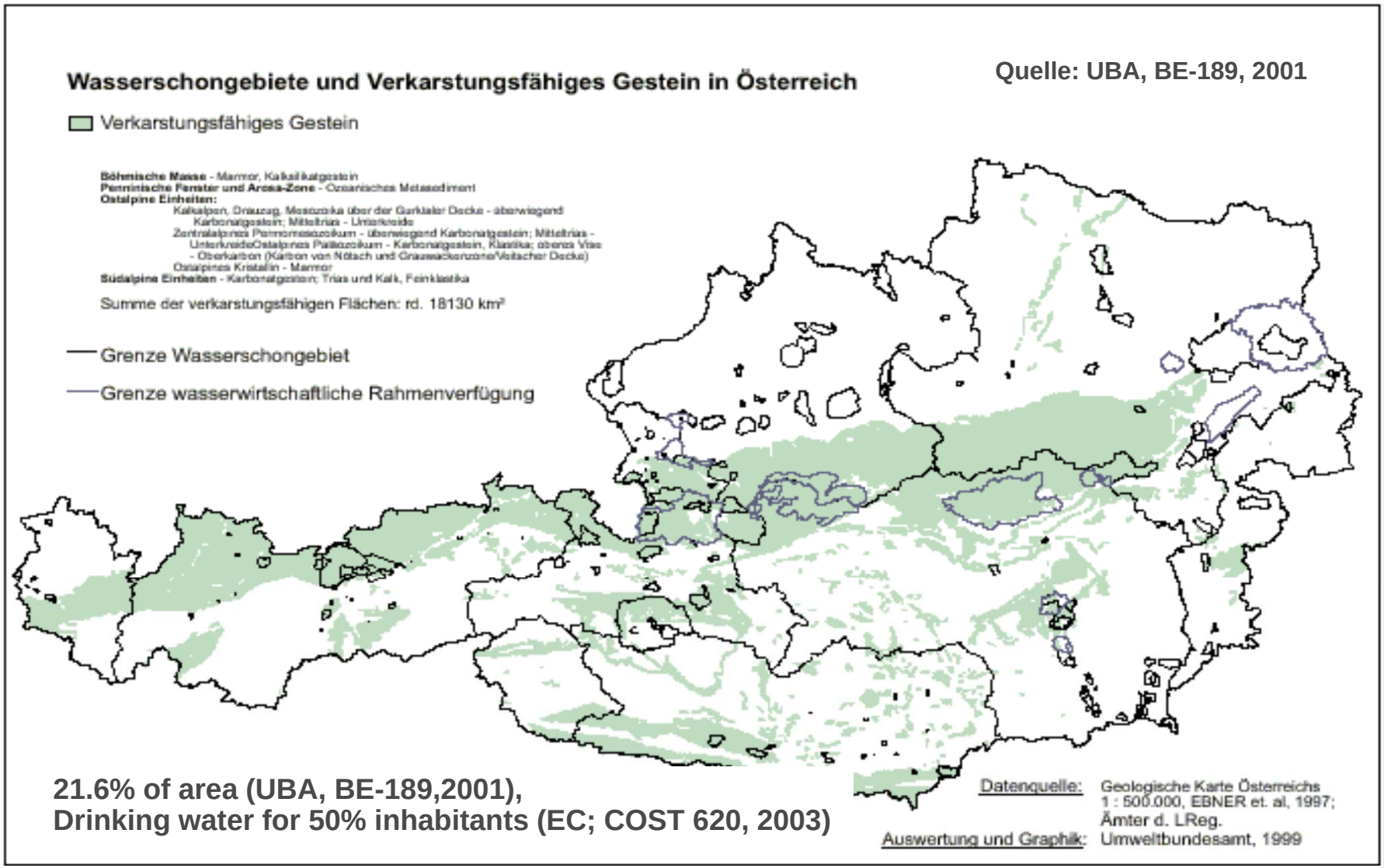


12.5% of land surface (Maritin & White 2008)

Drinking water for 25% of world population (www.karstwater.org)

Karte: Ford & Williams(2007): Karst Hydrology and Geomorphology

Karstifiable rocks in Austria



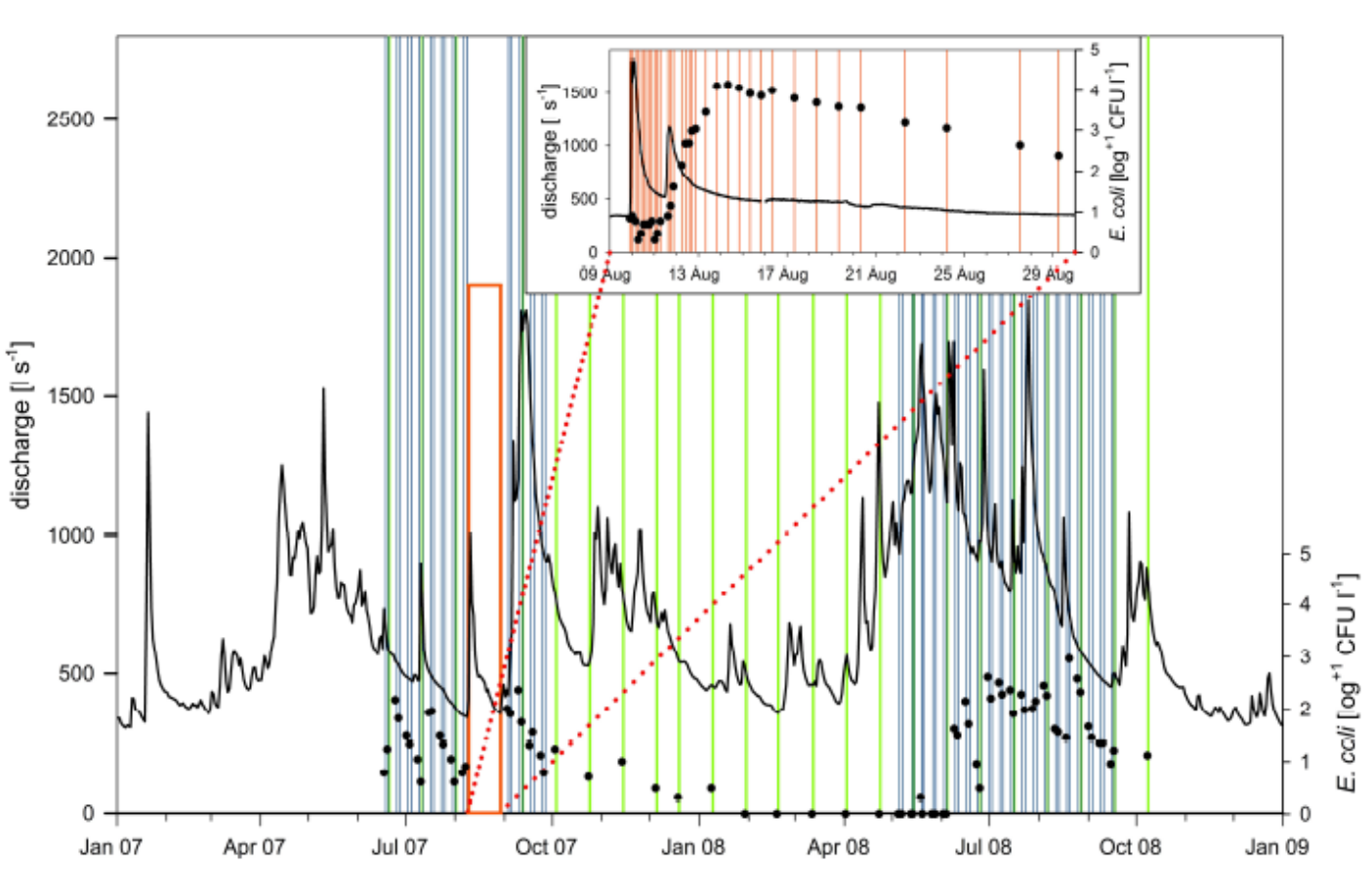
21.6% of area (UBA, BE-189,2001),
Drinking water for 50% inhabitants (EC; COST 620, 2003)

Applying a nested sampling design ....

Basic Monitoring
- all 3 to 4 weeks

High Frequency Monitoring (HFS)
- 2 weekly (summer)

Event Monitoring
>> resolution
- hours to days



… using automated event sampling …

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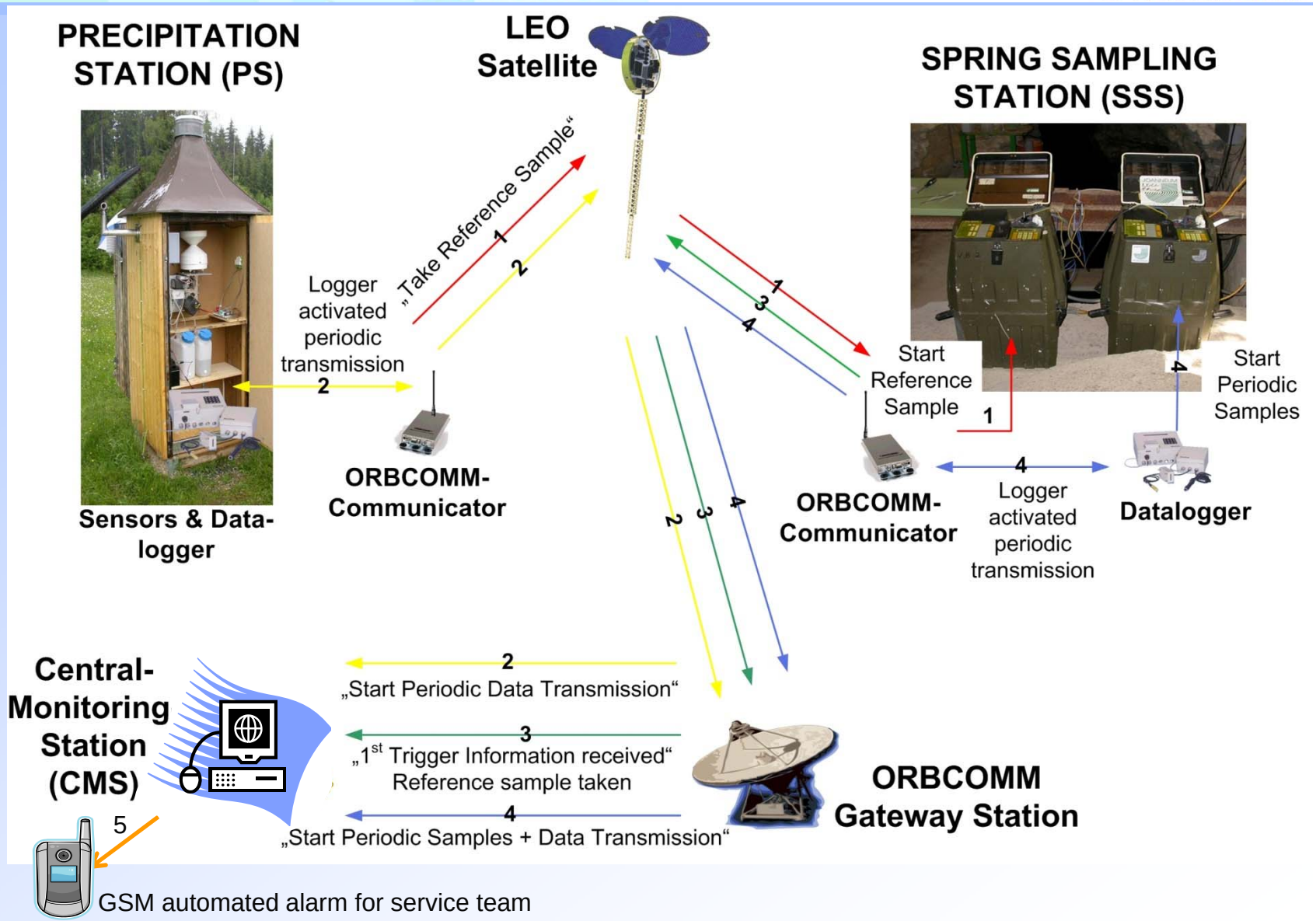

EXAMPLES

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EVENT MONITORING AND SAMPLING
is an
ESSENTIAL and UNIVERSAL TOOL
to identify distinct processes
on catchment and ecosystem scale

1) Insight to **biosphere**: microbial dynamics

2) Insight to **pedosphere**: nitrate leaching and soil characteristics

3) Insight to **airborne** pollutants and dynamics: environmental isotopes

E1

EXAMPLES

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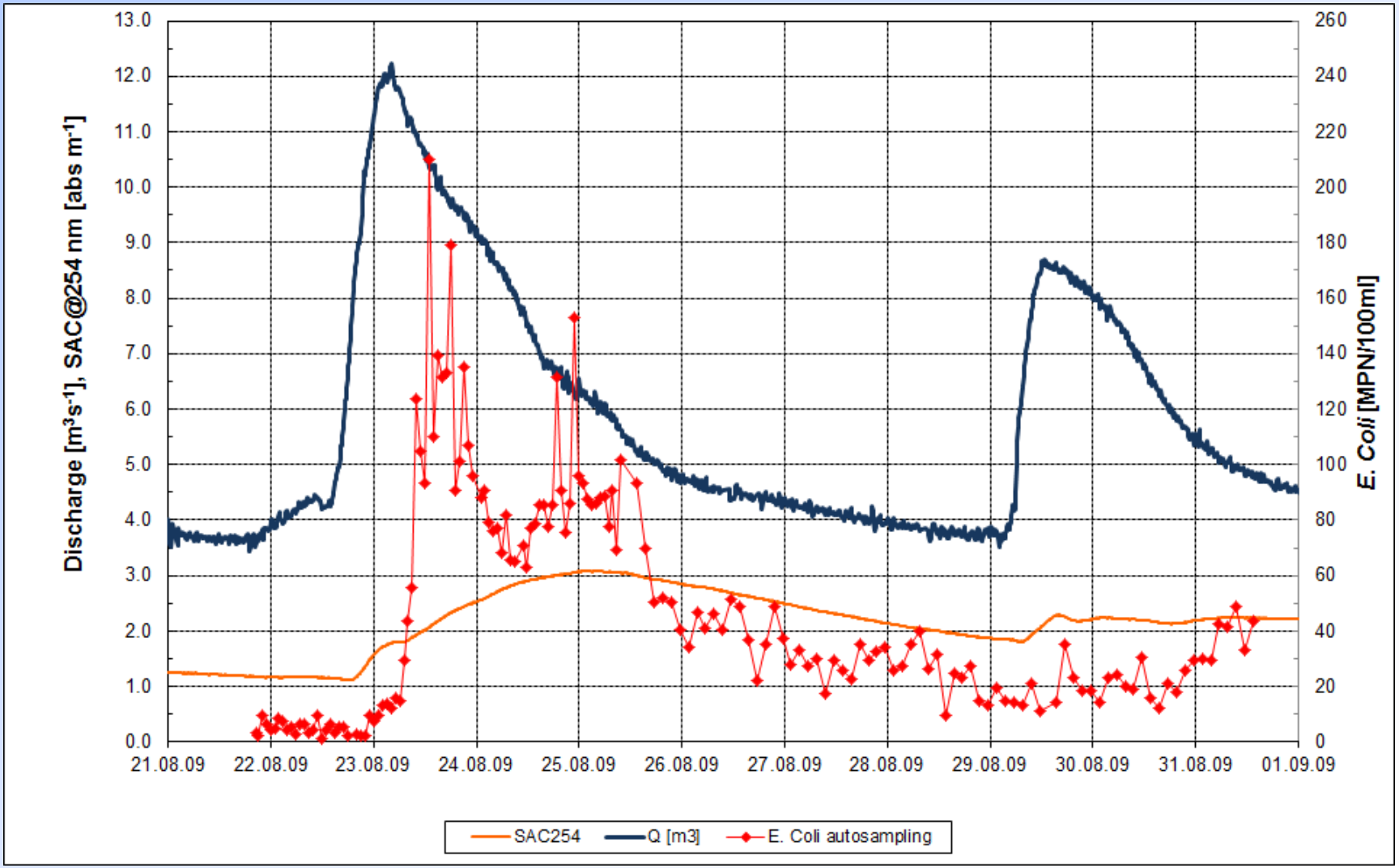
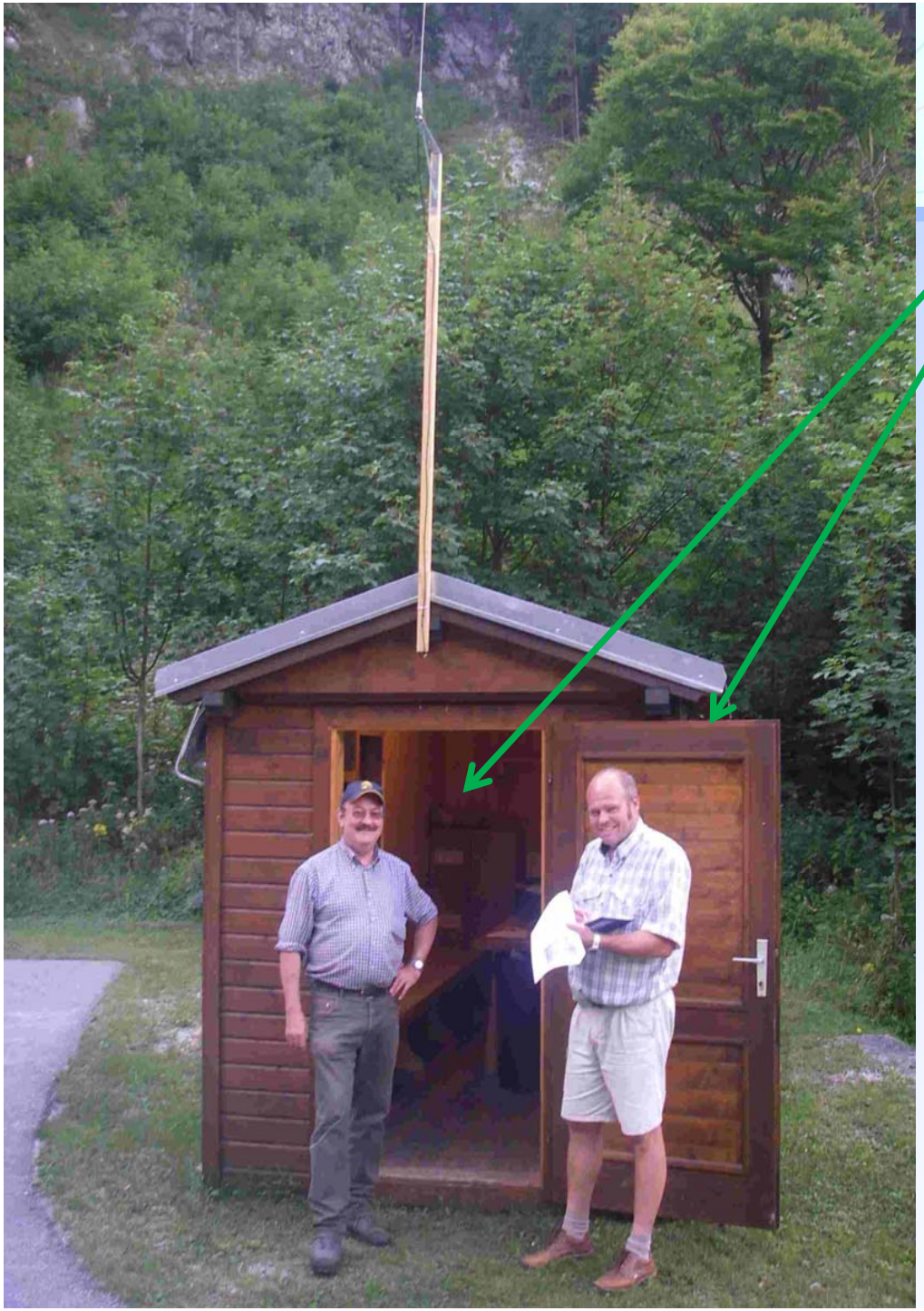
EXAMPLE 1

Microbial dynamics and SAC254



Is *E.coli** standard determination possible directly at the spring?

* recommended standard parameter for fecal pollution monitoring in drinking water



YES!

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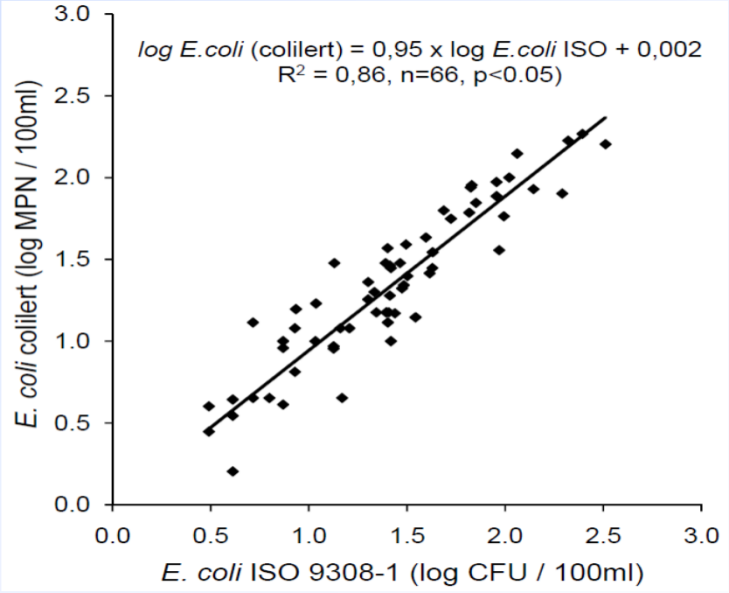
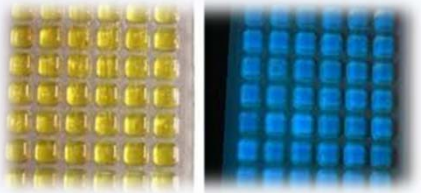
...happy staff during field testing



✓ available field methods



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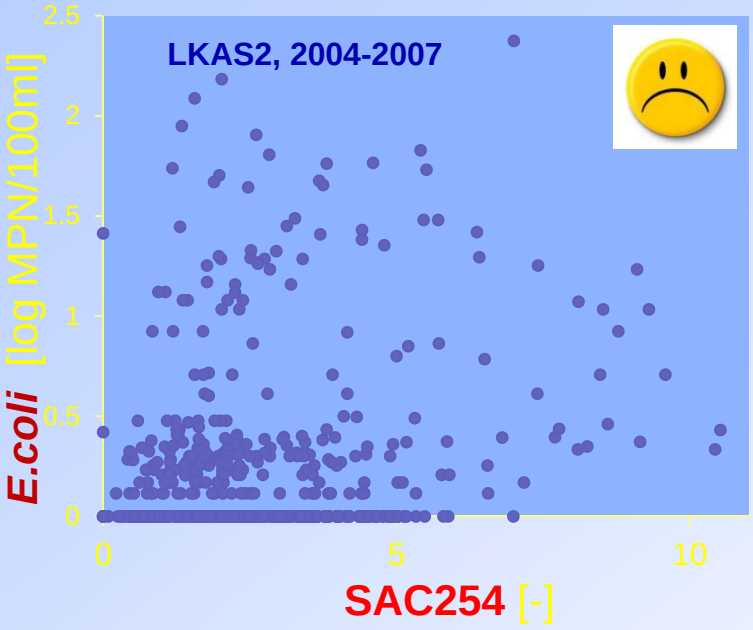
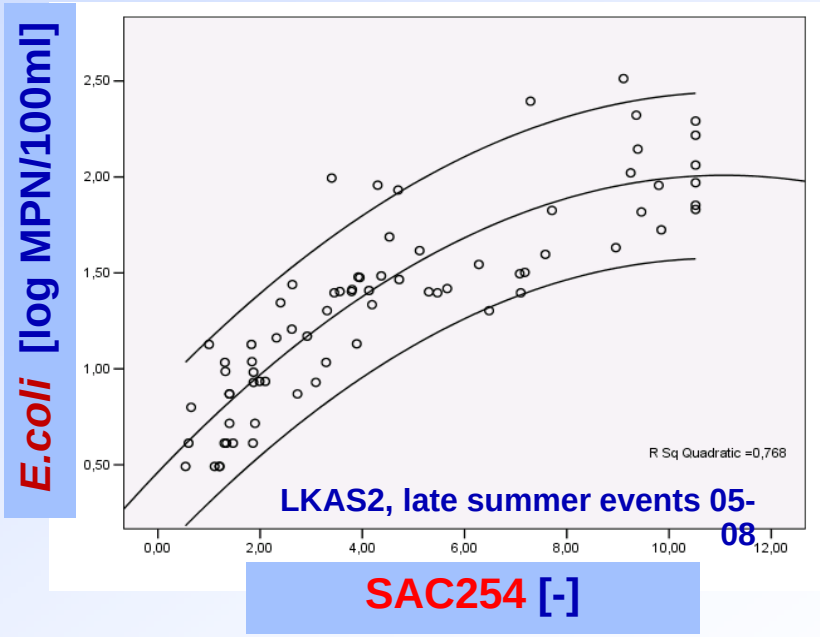
SAC254 a useful proxy parameter for near-real-time monitoring of fecal pollution in spring water from surface runoff!

The Spectral Absorption Coefficient $_{254nm}$ (SAC254)

- surrogate for dissolved organic carbon (DOC)



NO general relationship!

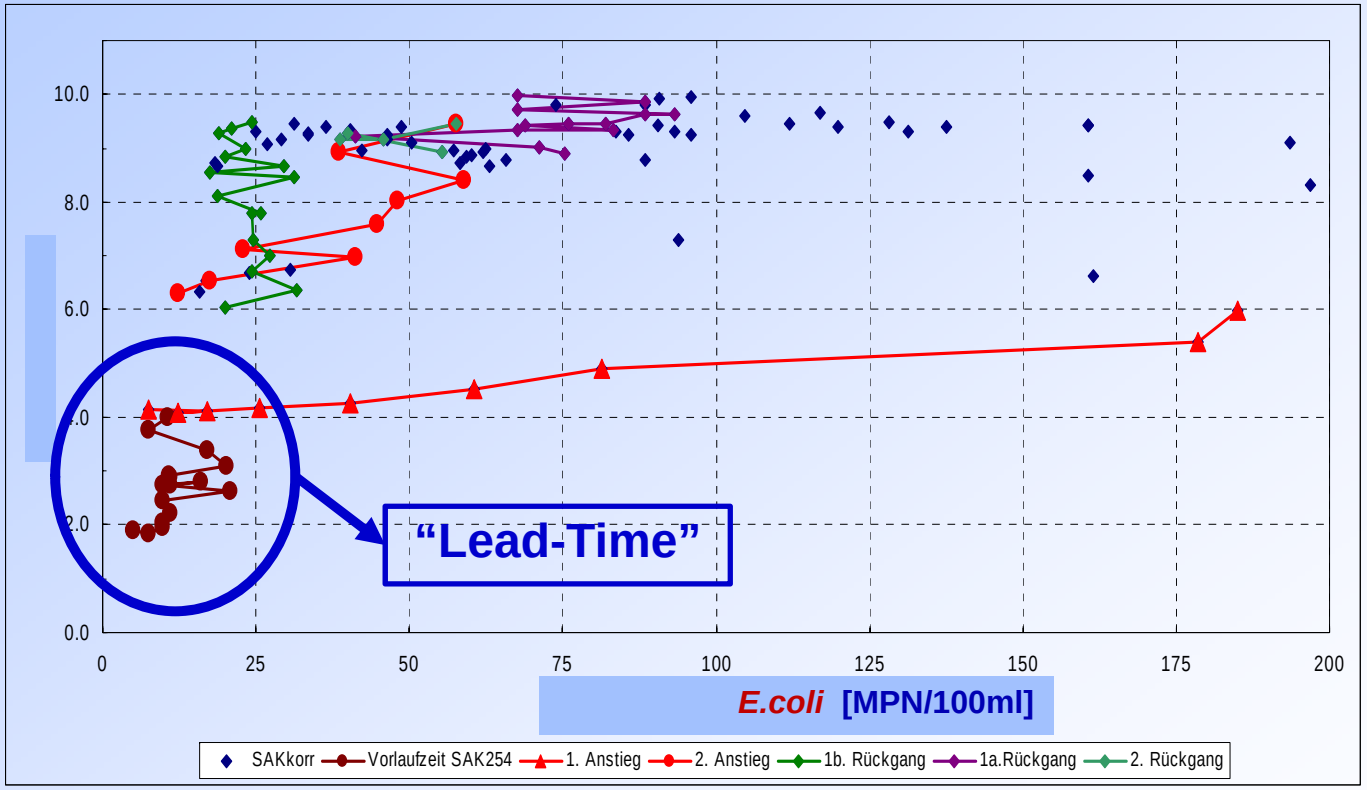


only for comparable situations
(event type, catchment situation)

Stadler, H., Klock, E., Skritek, P., Mach, R.L., Zerobin, W. and **Farnleitner, A.H.** (2010) The spectral absorbance coefficient at 254nm as a near real time early warning proxy for detecting faecal pollution events at alpine karst water resources *Water Science and Technology.* **62**(8):1898-1906.

E1

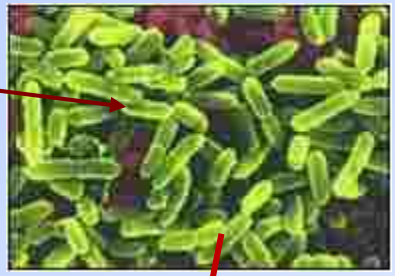
.....another possibility to use the SAK254?



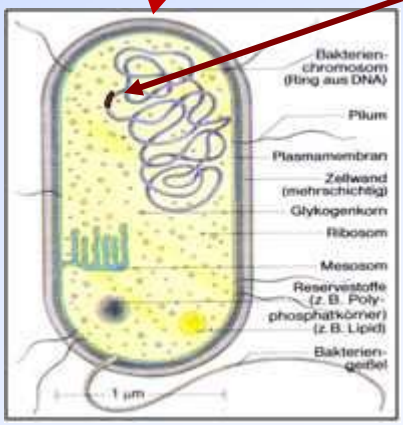
→ **All** event investigations showed a pronounced "**lead time**"
(different springs, catchment situations, hydrology)
→ **SAC254 = a very useful early warning proxy!**

E1 …detecting genetic fecal markers in water….

Bacteroidetes sp.
(ca. $10^{11\text{-}12}$ cells per g faeces)



short diagnostic DNA fragment (16S rDNA sequence)



quantitative detection by qPCR from DNA extracts (water sample)

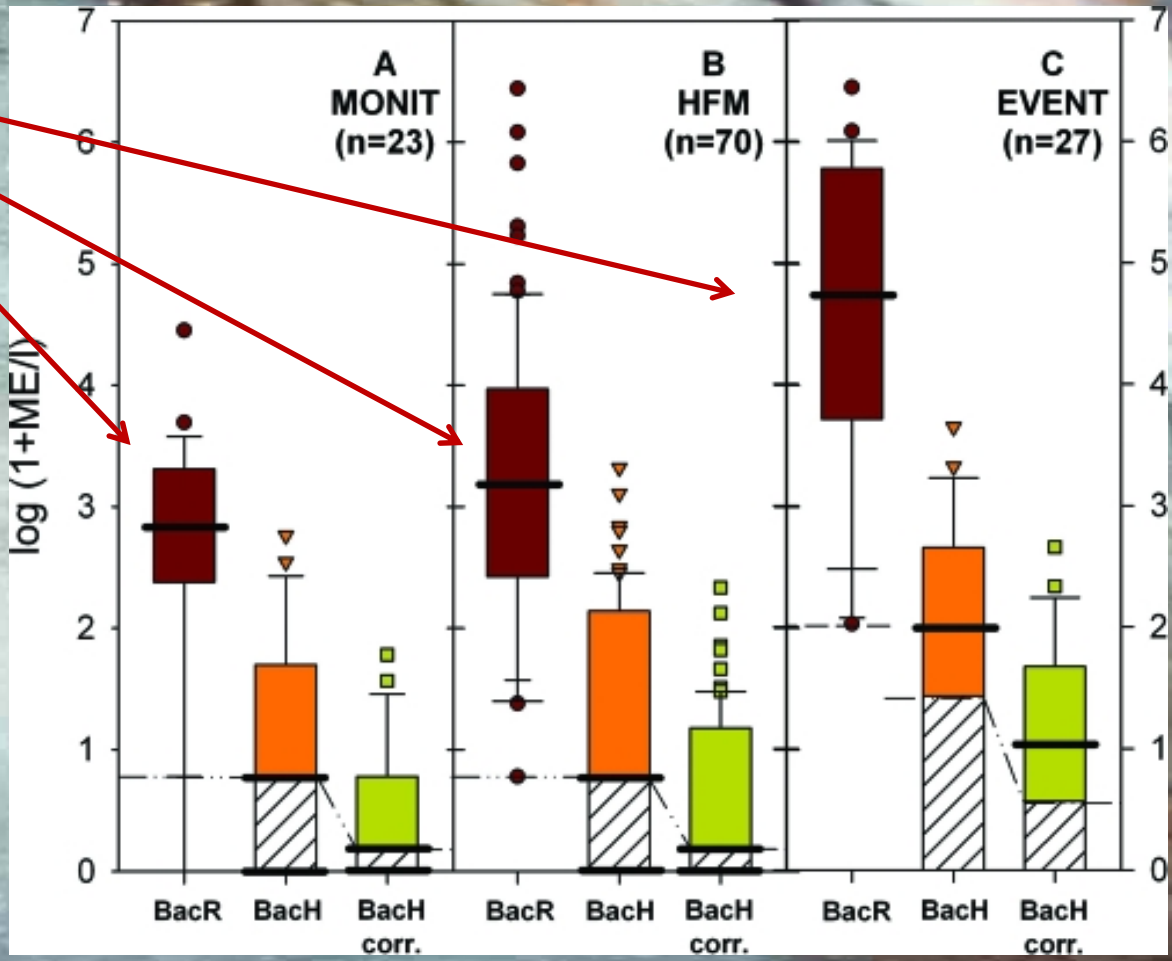
BacR ≡ ruminant specific (i.e. cattle, deer, chamois)

BacH ≡ human specific

Reischer, G.H., Kasper, D.C., Steinborn, R., Mach, R.L. and Farnleitner, A.H. (2006) Quantitative PCR method for sensitive detection of ruminant faecal pollution in freshwater and evaluation of this method in alpine karstic regions. *Appl. Environ. Microbiol*. 72: 5610 - 5614

Quantification of genetic fecal markers in spring water

Ruminants: the causative source



Example LKAS2

E2

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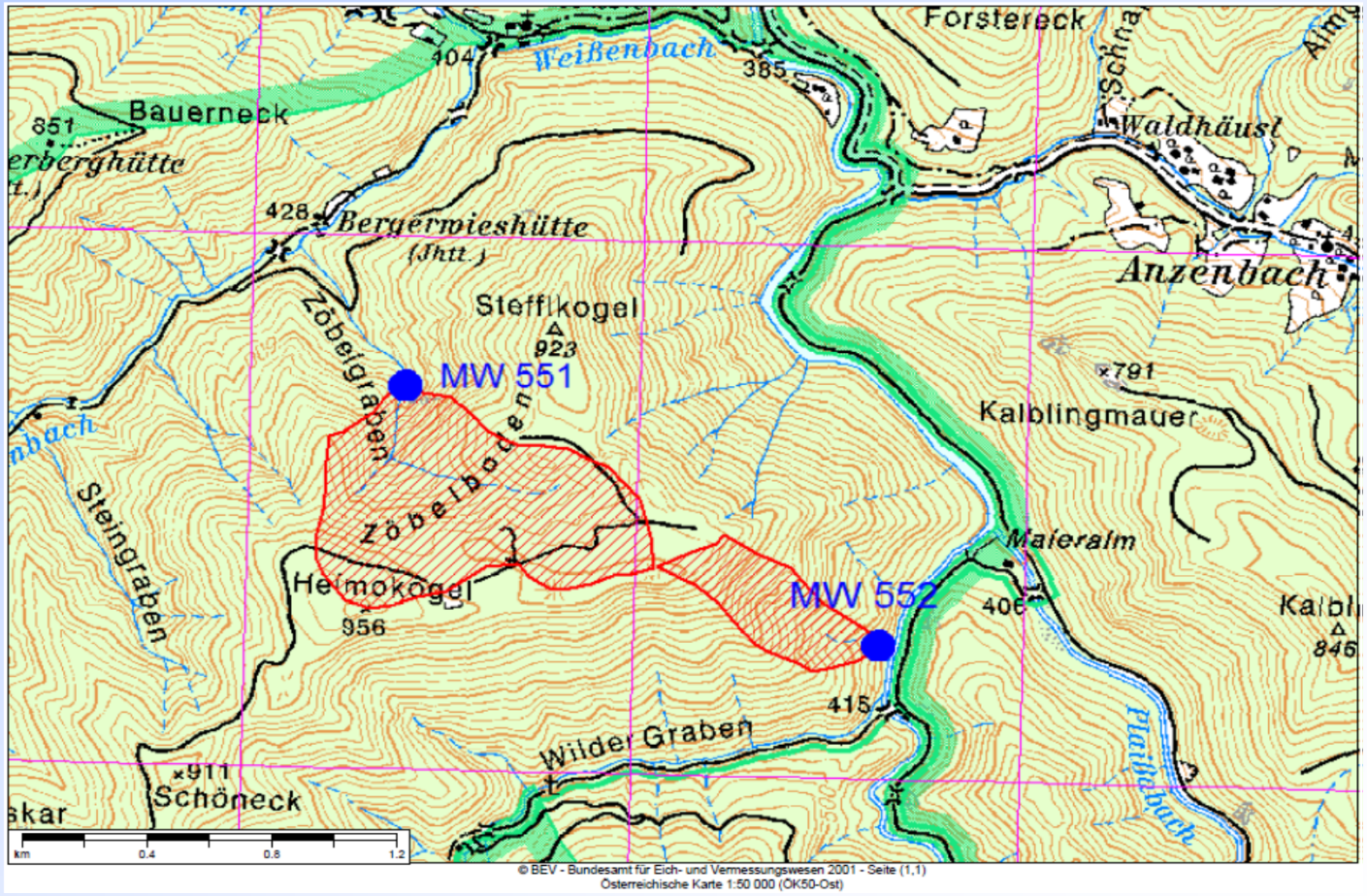
ZÖBELBODEN



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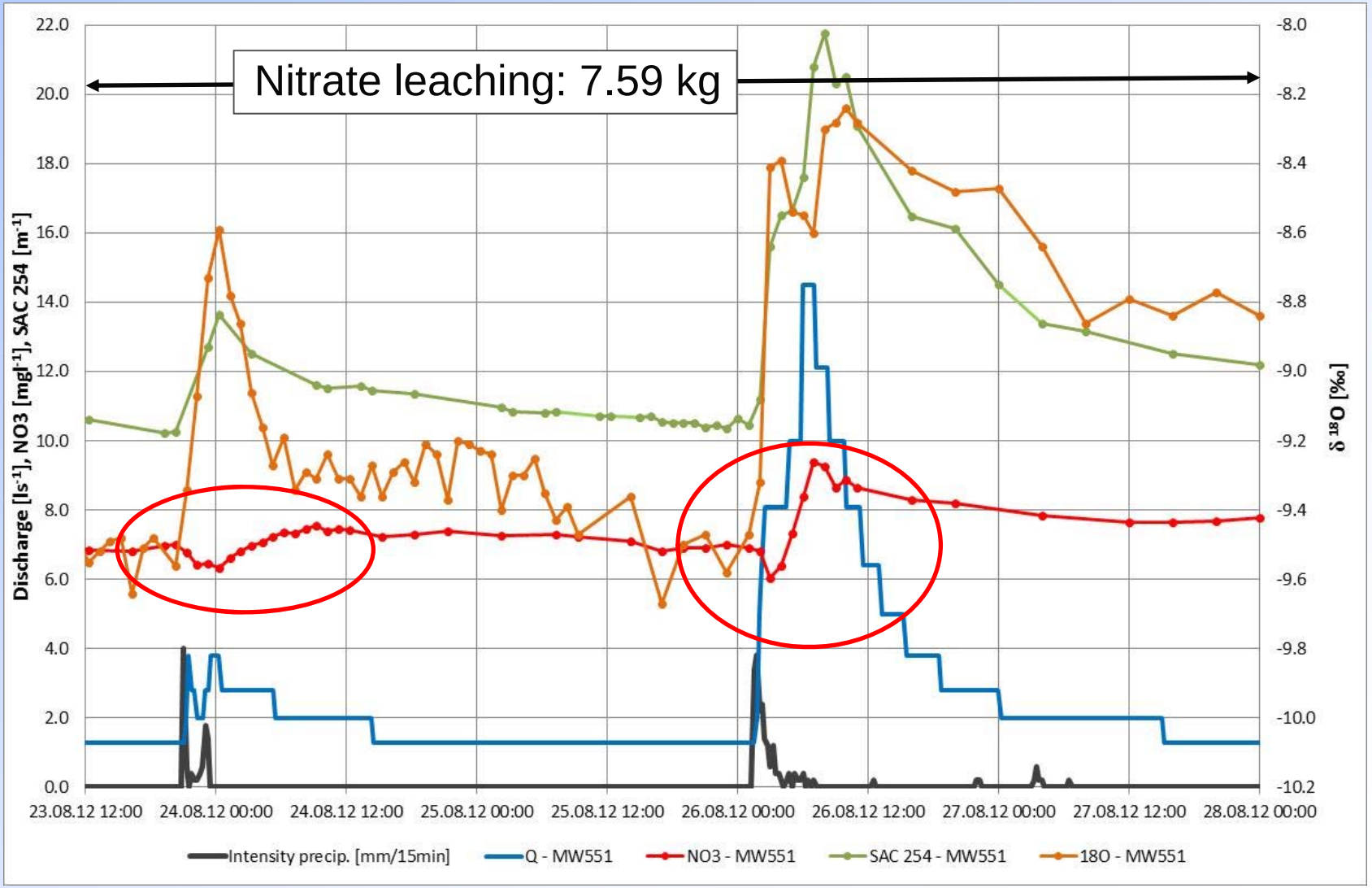
EXAMPLE 2

WATER – SOIL INTERACTION



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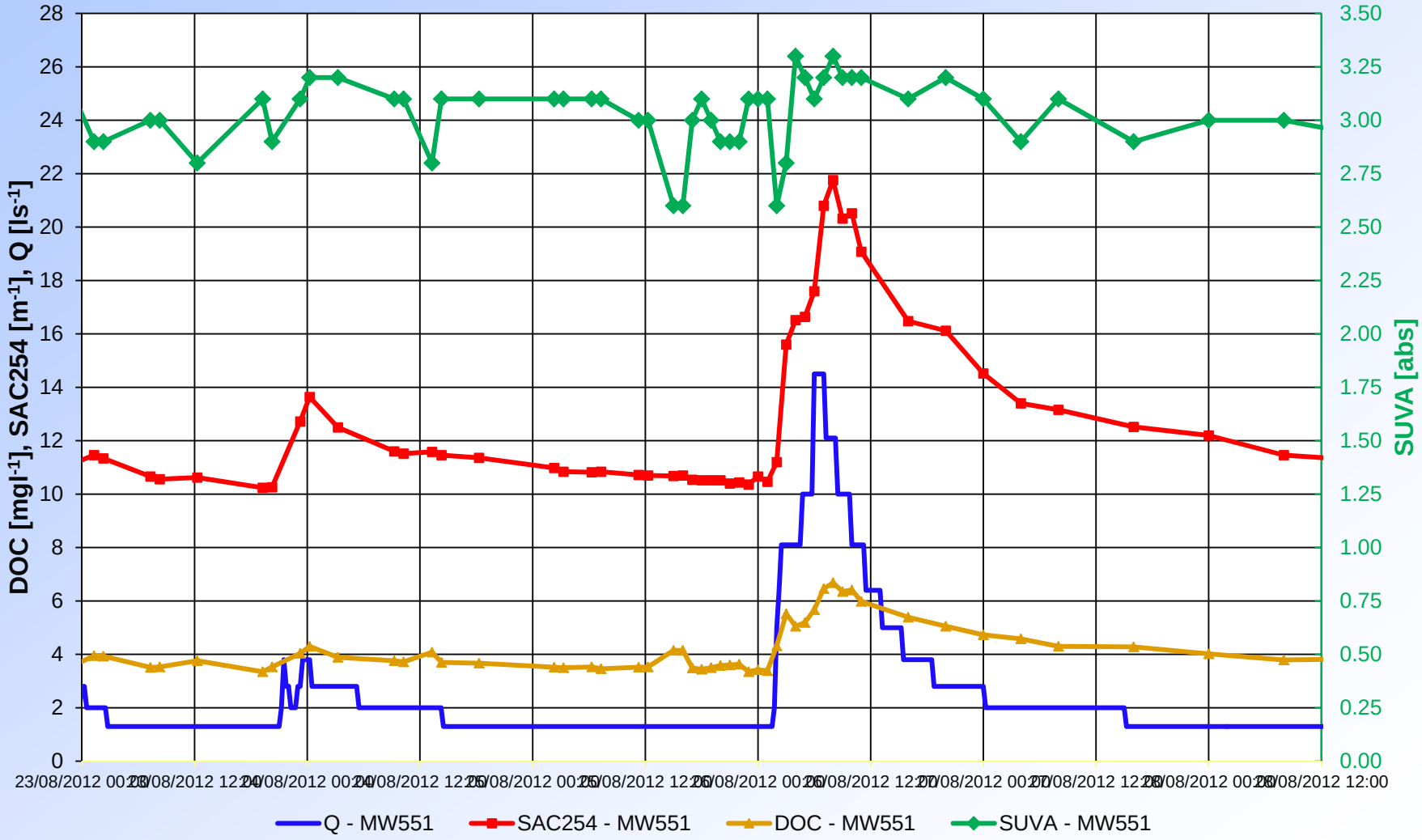

E3

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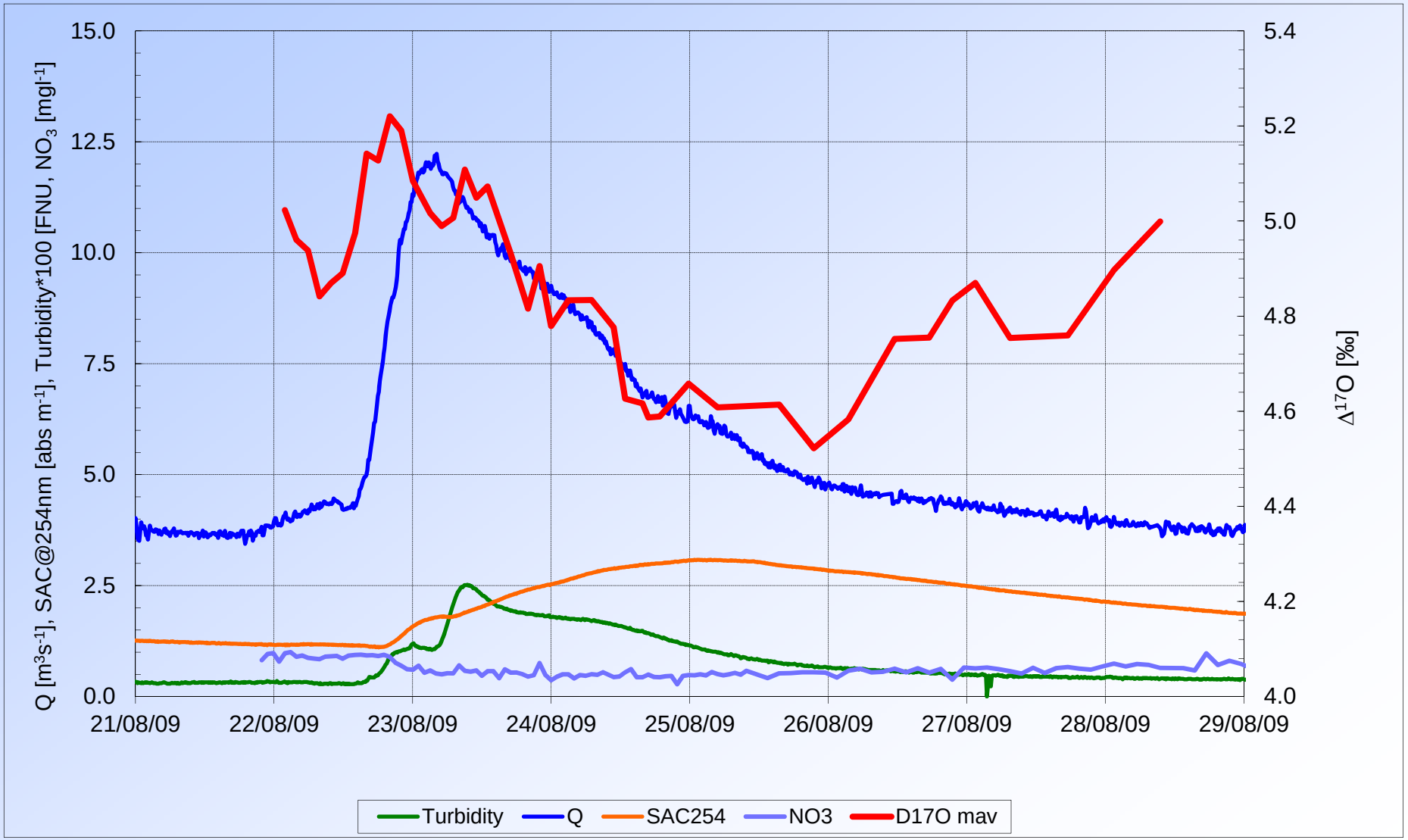
EXAMPLE 3

AIRBORNE POLLUTANTS



E3

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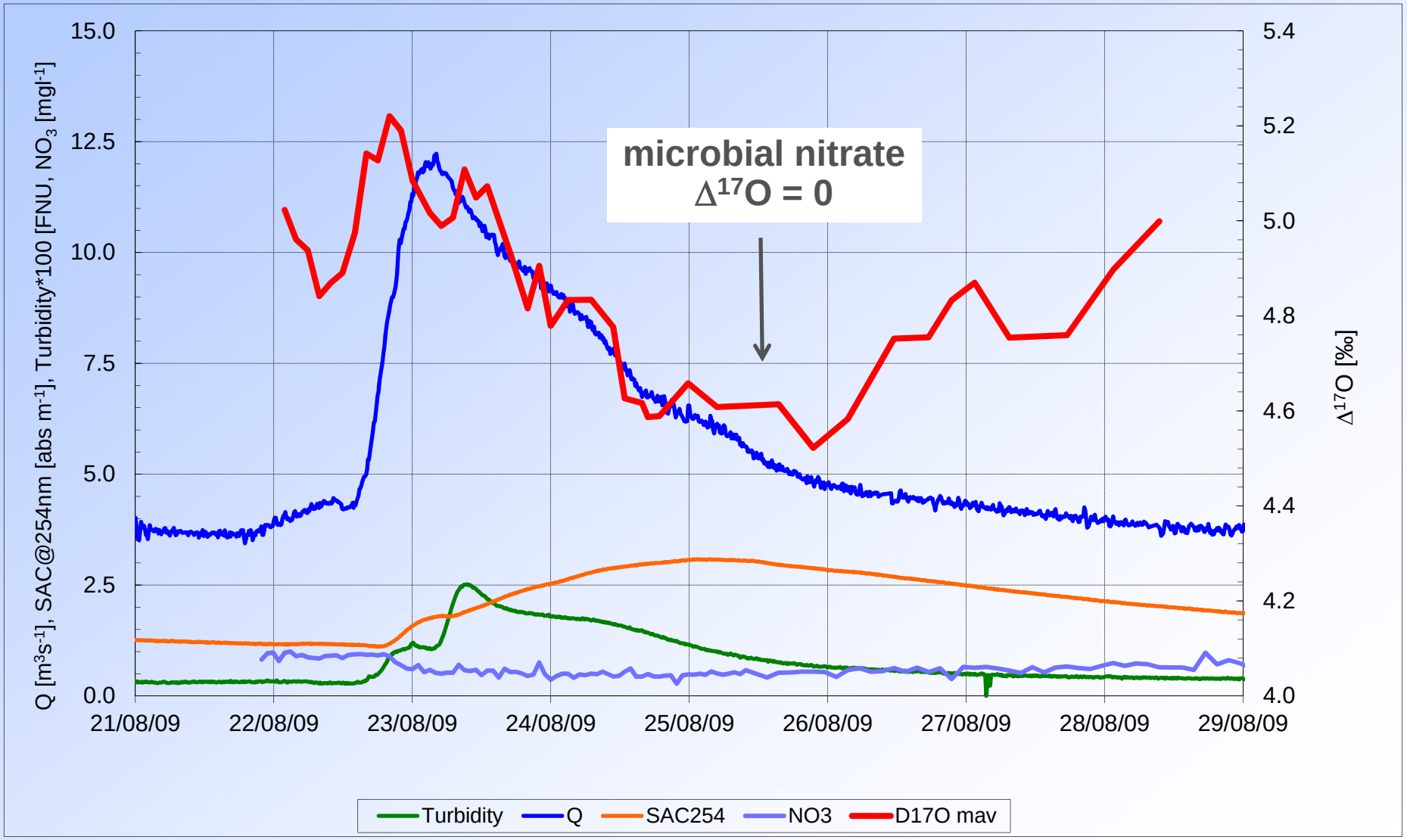

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RESULTS

EVENTMONITORING at KARST SPRING

ON-LINE MEASUREMENTS and LAB ANALYSES

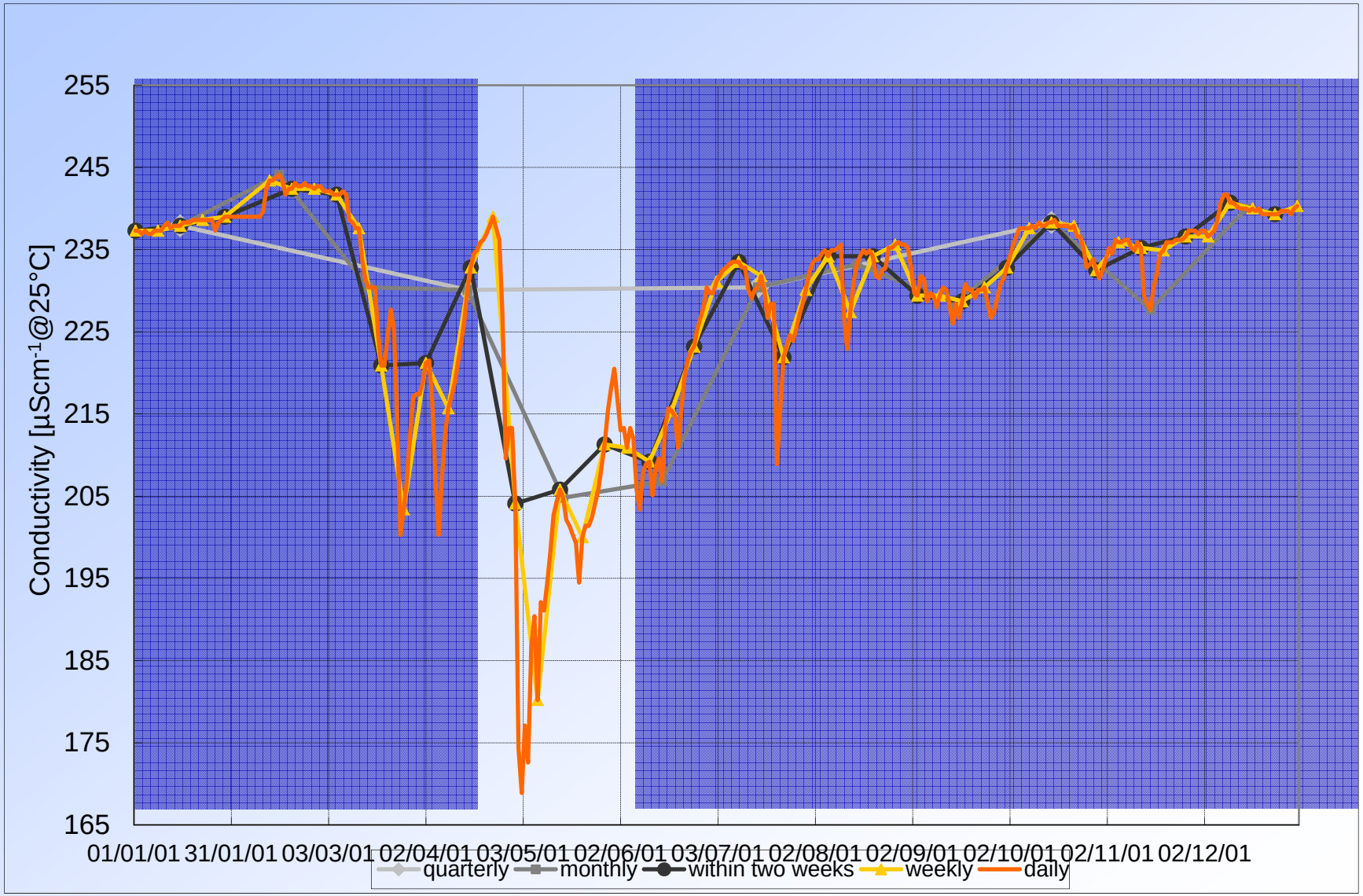
SYNOPSIS

- **Event monitoring and sampling is a ubiquitous tool**
- Nevertheless synopsis of different methods is necessary
- It is a joining element between different fields of research
- Helpful tool for establishing early warning systems
- Can identify dominant processes on (sub)-catchment scale.
- Adapted monitoring and sampling design is absolutely essential, based on nested sampling
- **Event monitoring is worse case monitoring** therefore a reliable base for modelling CC-effects on catchment and ecosystem scale
- Near real-time data transmission allows better project coordination and is essential for early warning systems


THANK YOU FOR
YOUR ATTENTION
mailto:Hermann.Stadler@joanneum.at

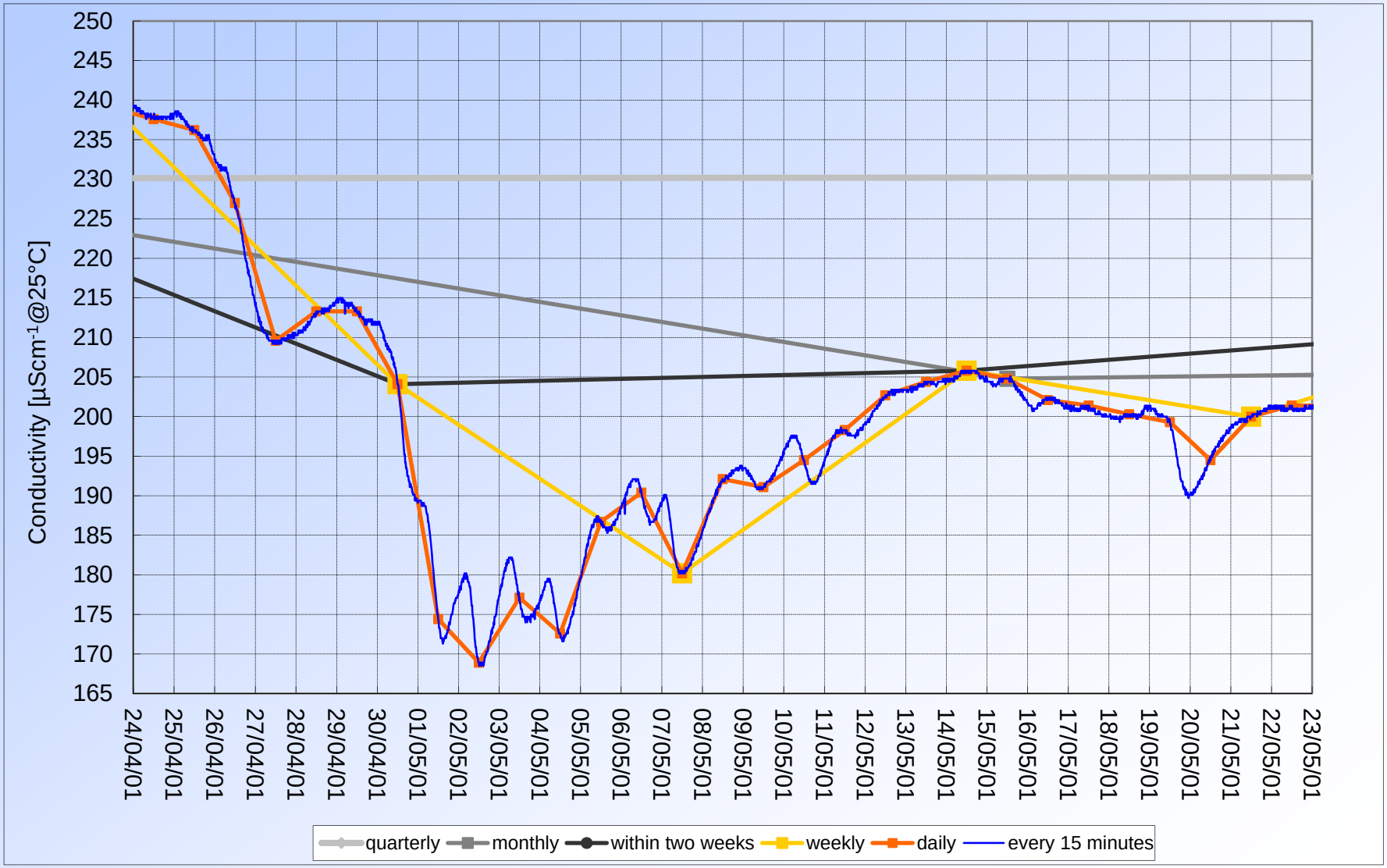
DYNAMIC and OBSERVATION INTERVALL (1)

CONDUCTIVITY at a KARST SPRING



DYNAMIC and OBSERVATION INTERVALL (2)

CONDUCTIVITY at a KARST SPRING



E3

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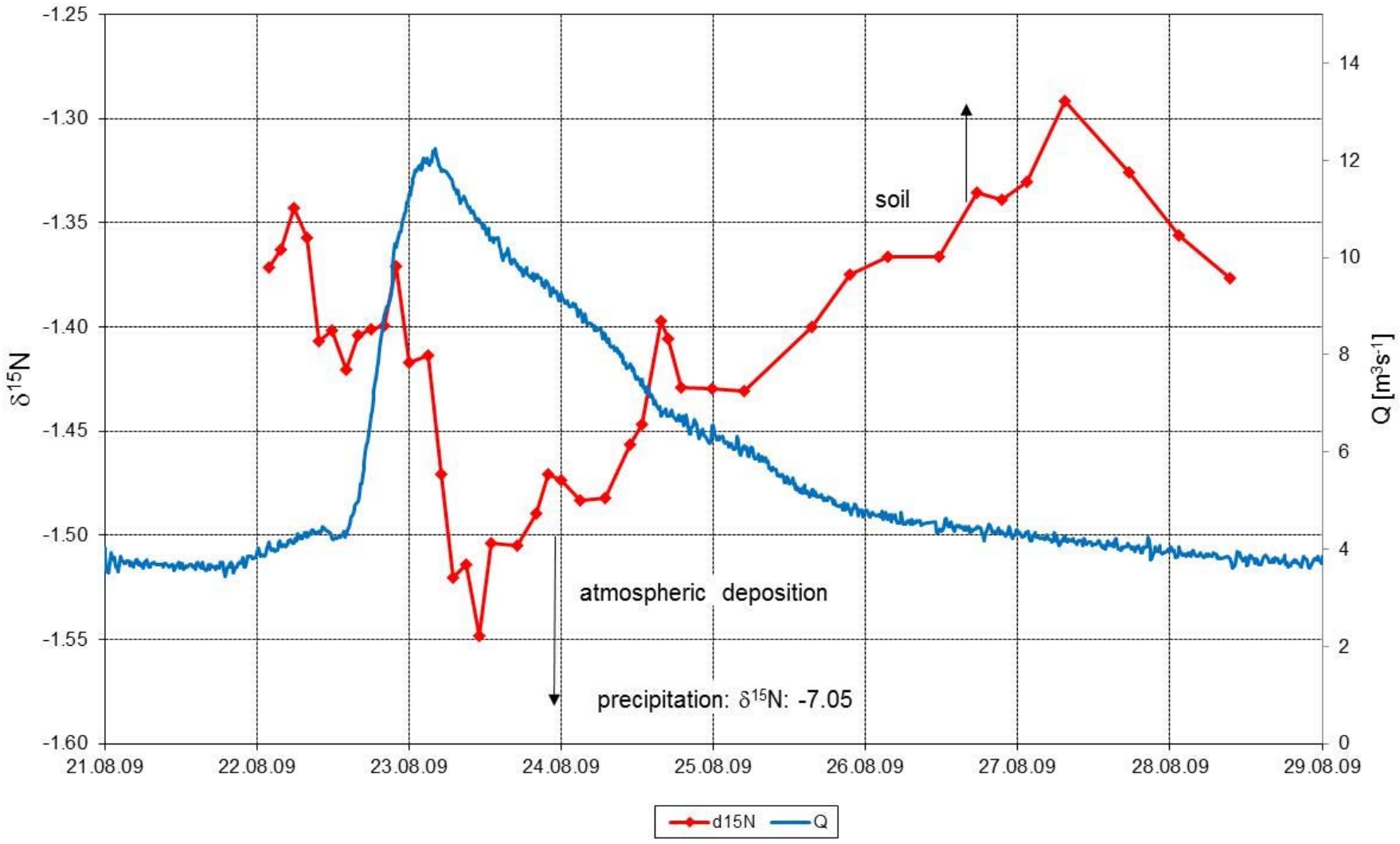
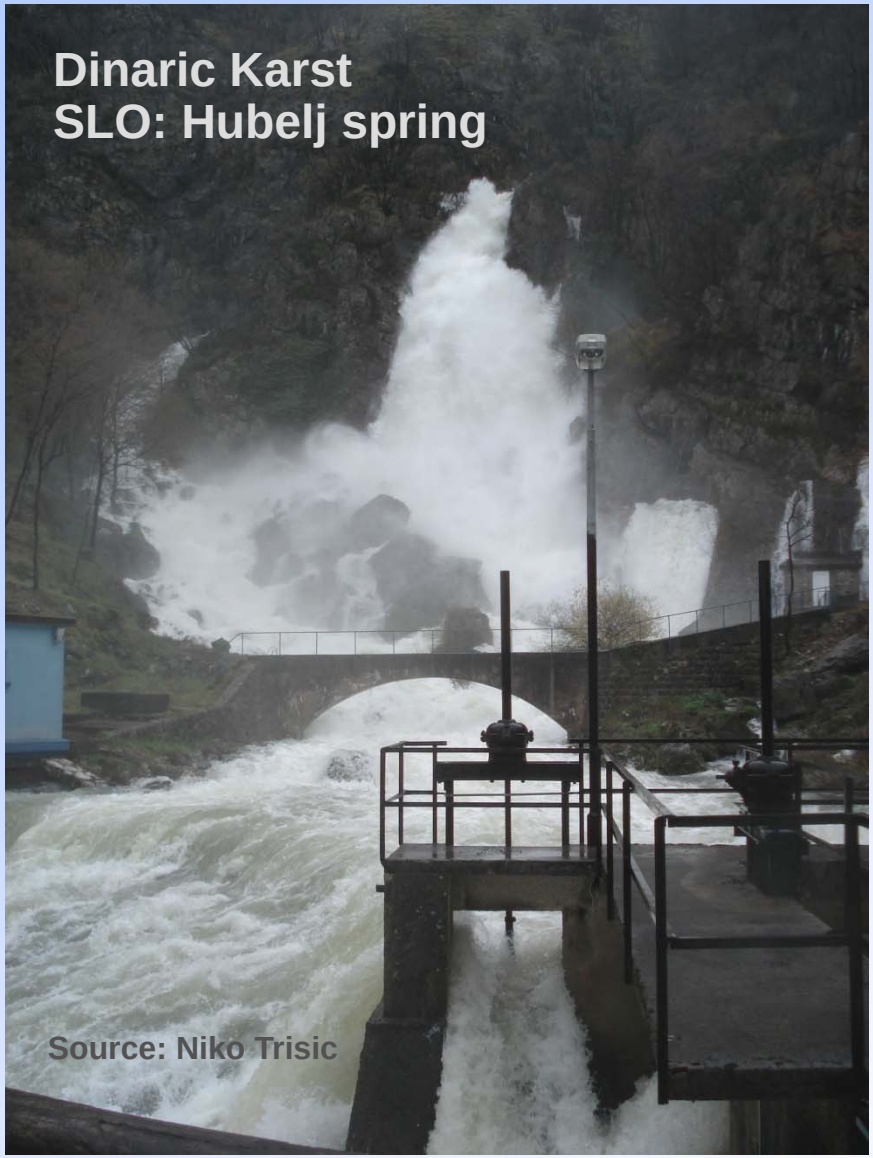


Karst springs



	BacR	BacH	EC	ENT	pCP	Aerob	HPC22	Dis	Turb	SAC_{254}
BacH	0.181									
EC	0.652*	0.117								
ENT	0.599*	0.004	0.814*							
pCP	0.330	0.029	0.491	0.536						
Aerob	0.370	0.026	0.343	0.605*	0.434					
HPC22	0.549	0.177	0.605*	0.687*	0.397	0.746*				
Dis	0.183	-0.071	0.079	0.227	0.024	0.645*	0.459			
Turb	0.426	0.294	-0.024	0.075	0.255	0.128	0.299	0.004		
SAC_{254}	0.444	0.064	-0.003	0.239	0.256	0.515	0.270	0.248	0.488	
Cond	0.146	-0.190	-0.162	-0.171	-0.199	-0.545	-0.479	-0.507	0.335	0.183

BMS
Basic Monitoring Sampling

(n=24)

	BacR	BacH	EC	ENT	pCP	Aerob	HPC22	Dis	Turb	SAC_{254}
BacH	0.262									
EC	0.913*	0.266								
ENT	0.884*	0.254	0.949*							
pCP	0.387	0.456*	0.427*	0.406*						
Aerob	0.565*	0.288	0.498*	0.539*	0.315					
HPC22	0.797*	0.285	0.798*	0.825*	0.440*	0.657*				
Dis	-0.037	-0.223	-0.209	-0.153	-0.156	0.386	0.040			
Turb	0.570*	0.320	0.417*	0.478*	0.328	0.605*	0.577*	0.323		
SAC_{254}	0.535*	0.181	0.420*	0.442*	0.159	0.696*	0.543*	0.538*	0.577*	
Cond	0.193	-0.079	0.275	0.219	-0.114	-0.298	-0.075	-0.276	-0.186	-0.101

HFS
High Frequency Sampling
(n=70)

	BacR	BacH	EC	ENT	pCP	Aerob	HPC22	Dis	Turb	SAC_{254}
BacH	0.112									
EC	0.916*	0.032								
ENT	0.869*	0.062	0.930*							
pCP	0.781*	0.167	0.838*	0.763*						
Aerob	0.893*	0.156	0.885*	0.934*	0.717*					
HPC22	0.909*	0.061	0.987*	0.934*	0.835*	0.882*				
Dis	-0.501	-0.432	-0.433	-0.420	-0.541	-0.458	-0.443			
Turb	0.814*	0.031	0.920*	0.922*	0.758*	0.883*	0.917*	-0.216		
SAC_{254}	0.831*	0.264	0.782*	0.798*	0.653*	0.843*	0.782*	-0.769*	0.655*	
Cond	-0.588*	-0.125	-0.612*	-0.581*	-0.763*	-0.622*	-0.623*	0.704*	-0.501	-0.697*

AES
Automated Event Sampling
(n=27)

RESULTS OF NESTED SAMPLING

Spearman Rank Correlation

* Spearman correlation significant on the <0.05 level (Bonferroni corrected for multiple testing)

3 TECHNICAL REALISATION

REAL-TIME DATA ACQUISITION

WEBSITE

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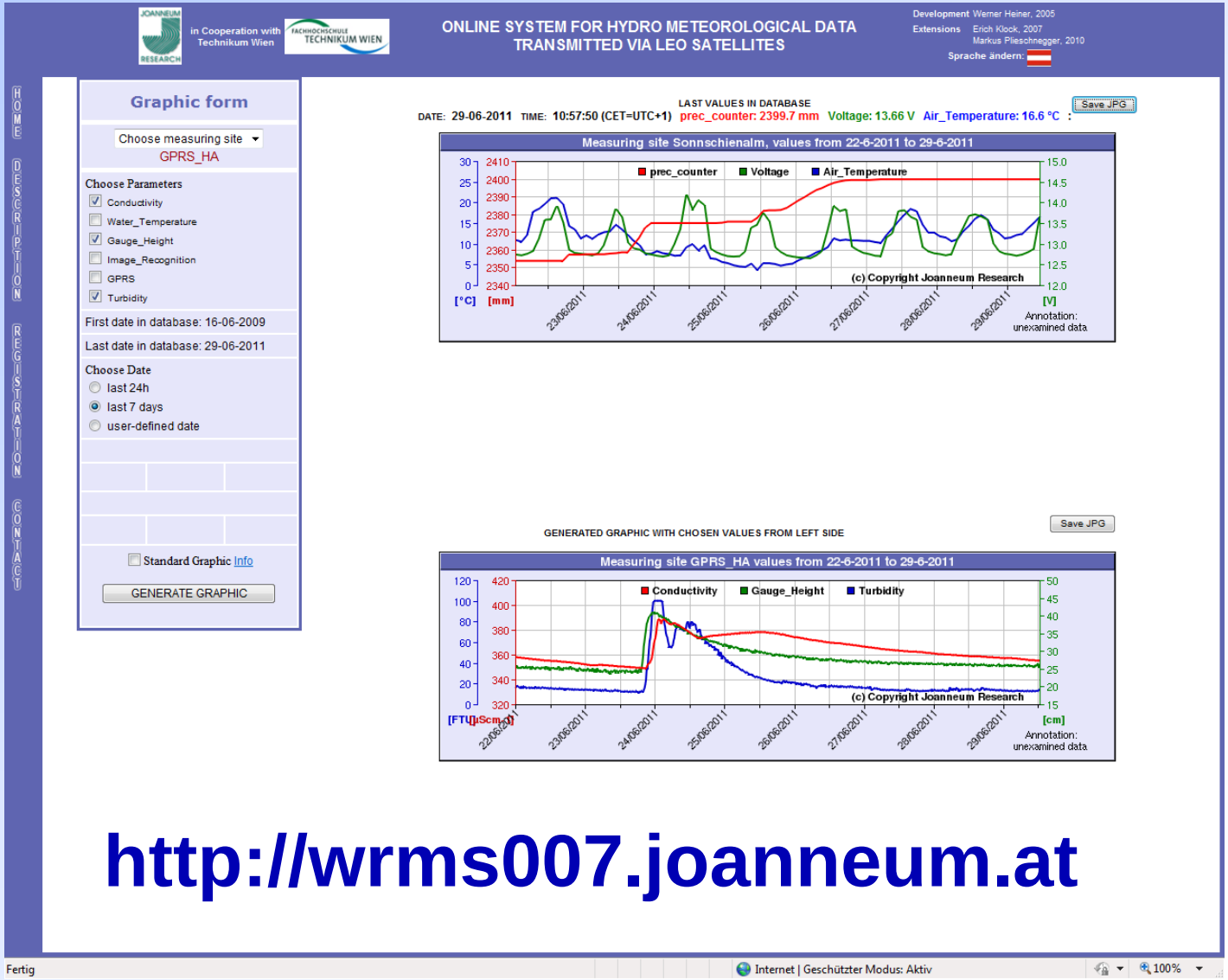
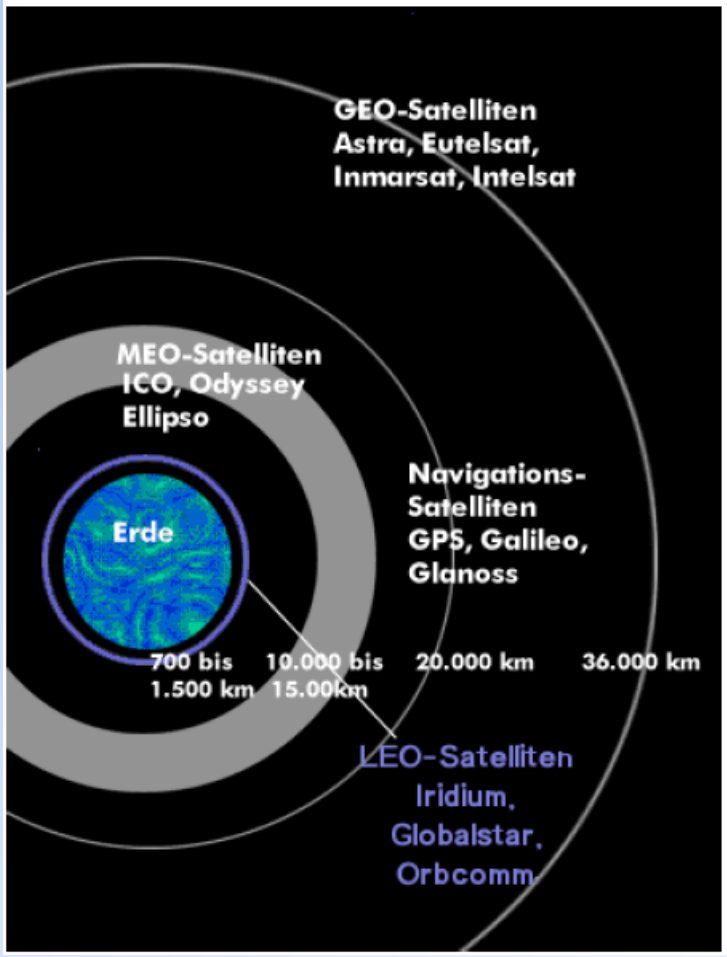
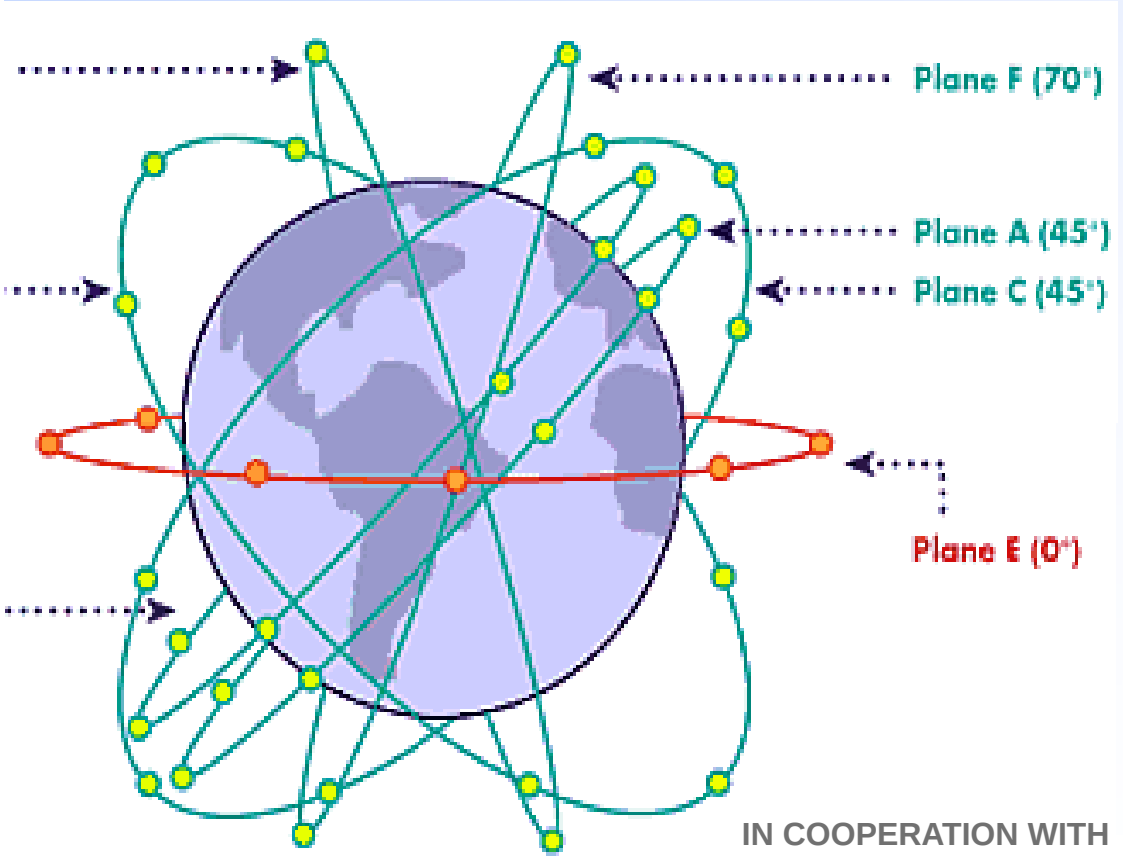


http://wrms007.joanneum.at

2 LEO SATELLITES





IN COOPERATION WITH

RESULTS

SAMPLING DESIGN

covering the whole dynamic

NESTED SAMPLING DESIGN

BMS……..BASIC MONITORING/SAMPLING

HFS……HIGH FREQUENCY SAMPLING

AES……AUTOMATED EVENT SAMPLING

TRIGGER TIMES and HYDROLOGICAL RESPONSE