Solute Transport Variability in Alpine Karst Aquifers under Different Flow Conditions

Nadine Göppert & Nico Goldscheider

Institute of Applied Geosciences, Hydrogeology Group

General Background and Research Focus

- Alpine karst aquifers represent important water resources but are strongly influenced by weather extremes and predicted climate change.

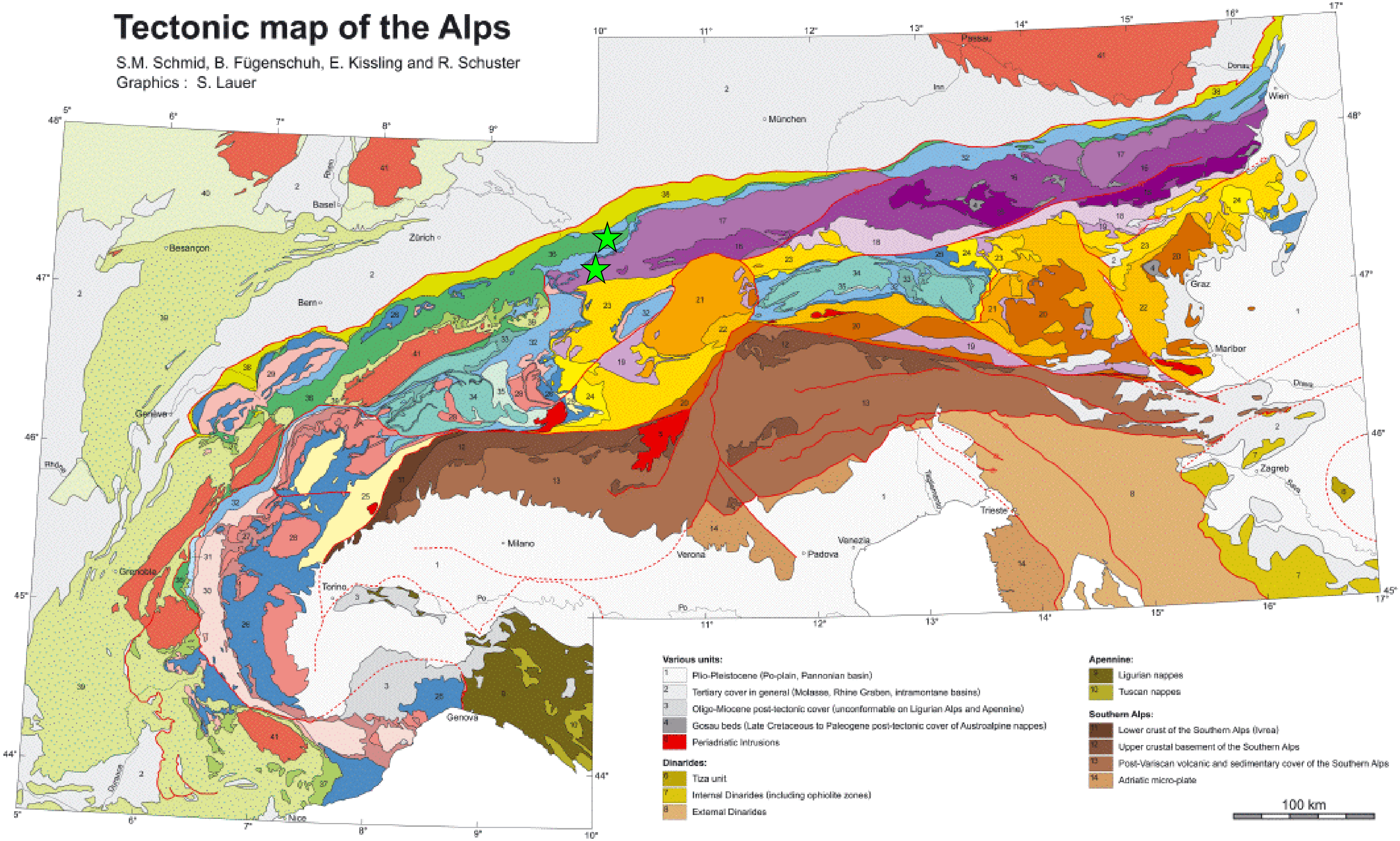
Research Question:

- What is the influence of the flow conditions on potential contaminant maximum concentrations in alpine karst systems?

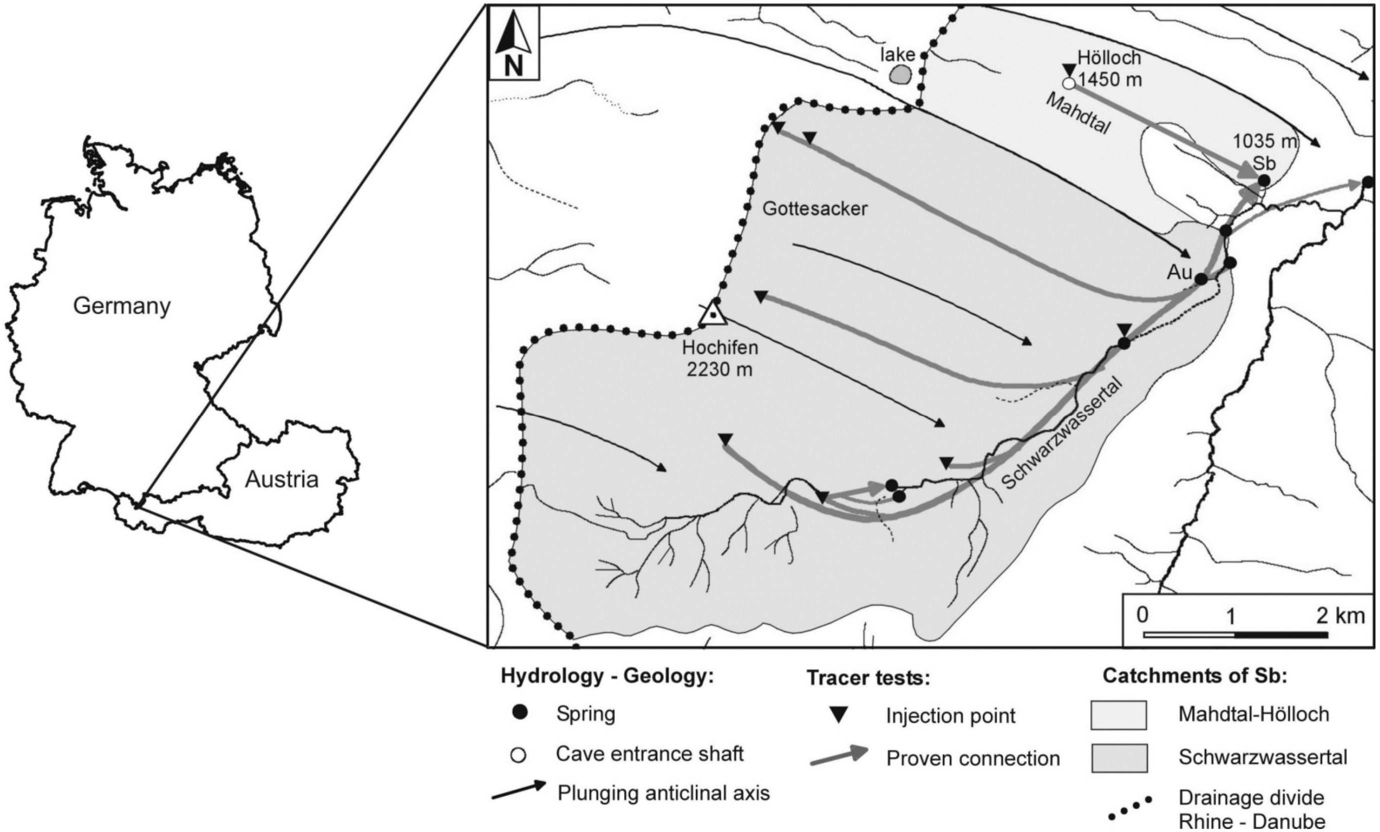
Method:

- Repeated tracer tests during high- and low-flow conditions, in different types of (alpine) karst systems.

Geology of the Alps and location of the test sites



Test site 1: Hochifen-Gottesacker, Hölloch



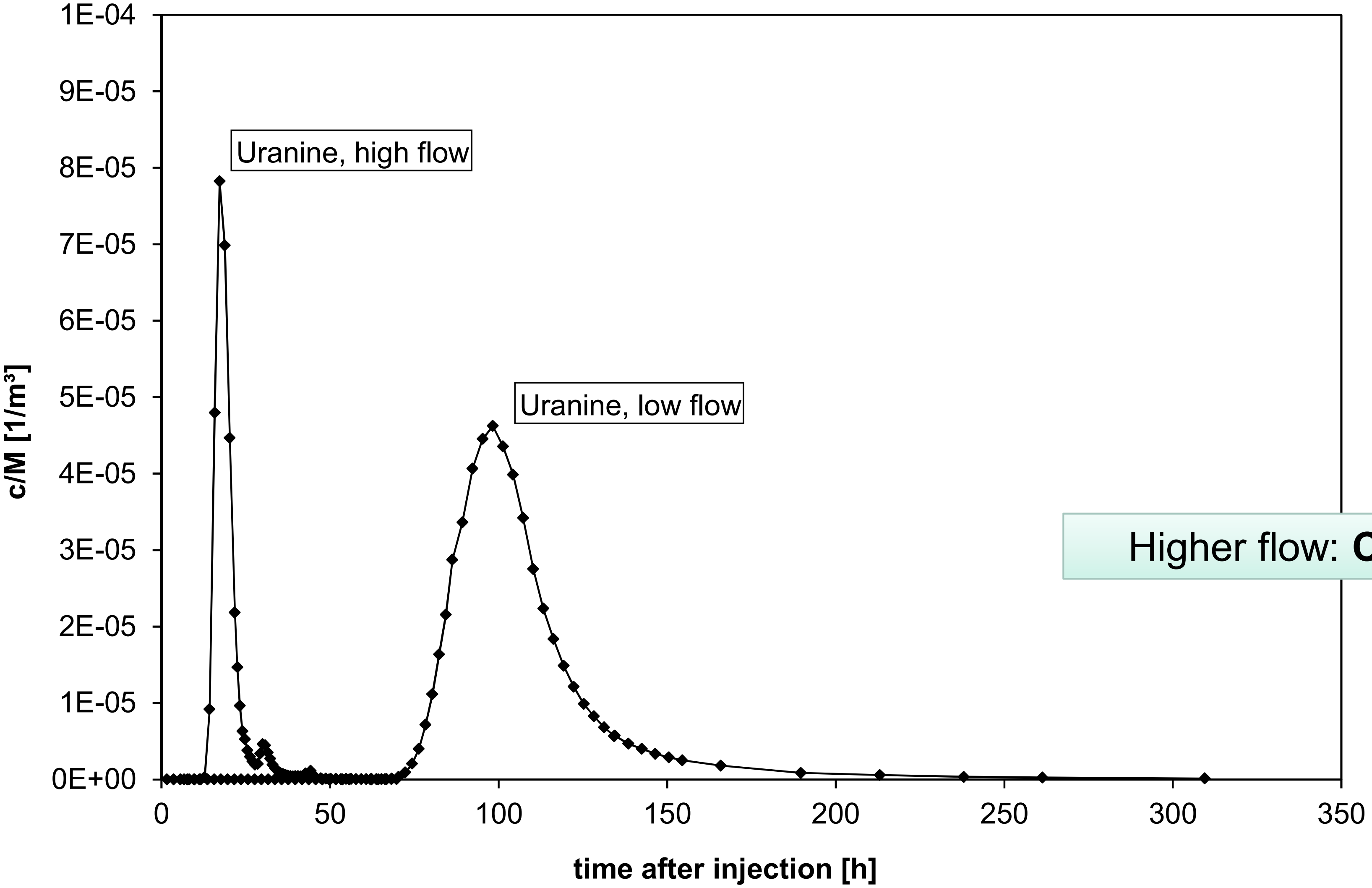
Two tracer tests (d = 2300 m):

Low flow conditions, Q ~ 172 L/s

High-flow conditions, Q ~ 582 L/s

Göppert & Goldscheider (2008) Ground Water

Comparison between high-flow and low-flow conditions



Higher flow: **C↑**

Test site 2: Lechquellengebirge (*Lech Spring Mountains*)

Large regional karst aquifer system… with some small and local epikarst flow systems that are ideal experimental sites for tracer tests (d = 227 m).

Swallow hole: tracer injections

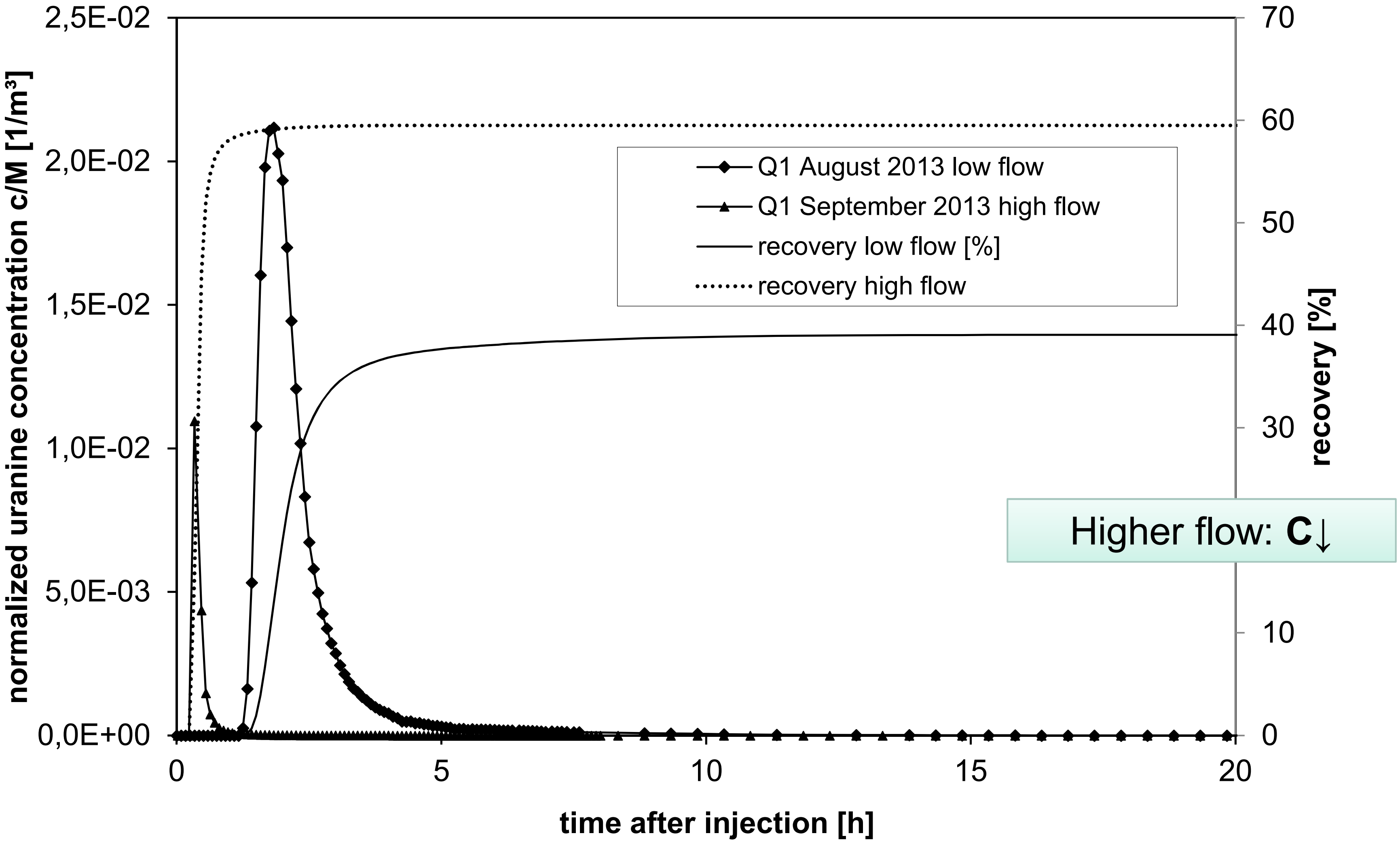
Epikarst spring: main sampling site

Two tracer tests:

Low flow conditions, Q ~ 9 L/s

High-flow conditions, Q ~ 77 L/s

Comparison between high-flow and low-flow conditions



Quantitative interpretation

Advection-Disperion Model (ADM) for tracer transport

$$c(t) = \frac{M}{Q t_0 \sqrt{4\pi p_D \left(\frac{t}{t_0}\right)^3}} \exp\left(-\frac{\left(1-\frac{t}{t_0}\right)^2}{4 P_D \frac{t}{t_0}}\right)$$

Kreft & Zuber 1978

Comparison of low- and high-flow conditions

$$\frac{c_{p,h}}{c_{p,l}} = \frac{(v/Q)_h}{(v/Q)_l}$$

Göppert & Goldscheider 2008

c_p = peak concentration
v = velocity
Q = discharge
h/l = high / low-flow conditions

Higher Q means higher velocity and thus narrower tracer breakthrough curve (C↑) but also more dilution (C↓). Our formula is able to explain this effect.

Comparison of the two test sites

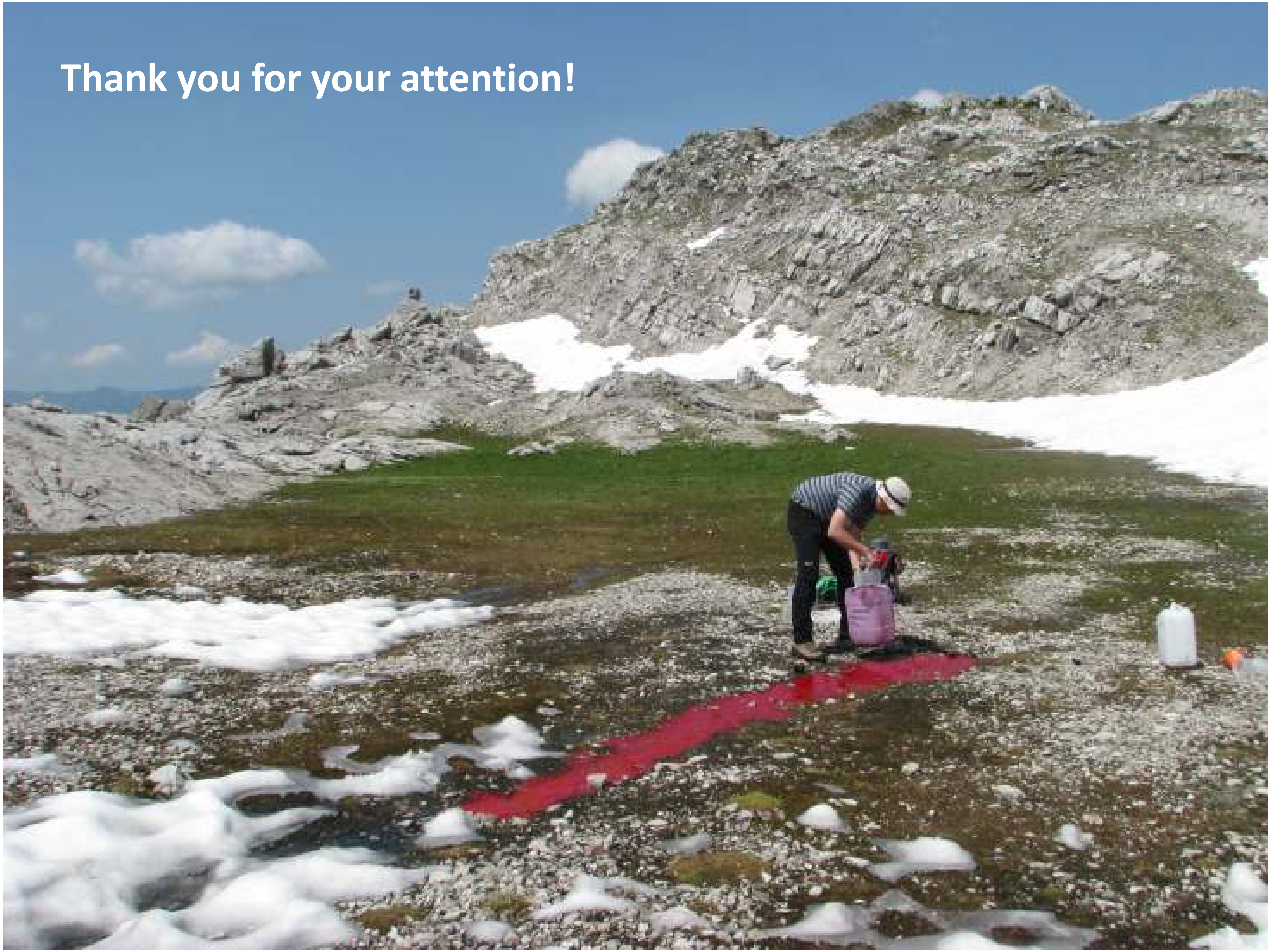
- Test site 1: Higher concentrations during high flow (ratio = 1.7).
- Dominating process: Higher discharge ➔ faster flow ➔ narrower breakthrough curve ➔ higher peak concentration.

$$\frac{c_{p,h}}{c_{p,l}} = \frac{(v/Q)_h}{(v/Q)_l} = 1.7$$

- Test site 2: Lower concentration during high flow (ratio = 0.5).
- Higher discharge ➔ more dilution ➔ lower peak concentration.

$$\frac{c_{p,h}}{c_{p,l}} = \frac{(v/Q)_h}{(v/Q)_l} = 0.5$$

➔ Helpful to predict the impact of extreme hydrologic events on maximum contaminant levels


Thank you for your attention!