

Using multiple field fluorometers to highlight dye behavior in karst conduits

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Dye tracing is a powerful tool in karst hydrogeology to specify groundwater flow routes, hydrogeological connections, karst conduits and aquifer characteristics.

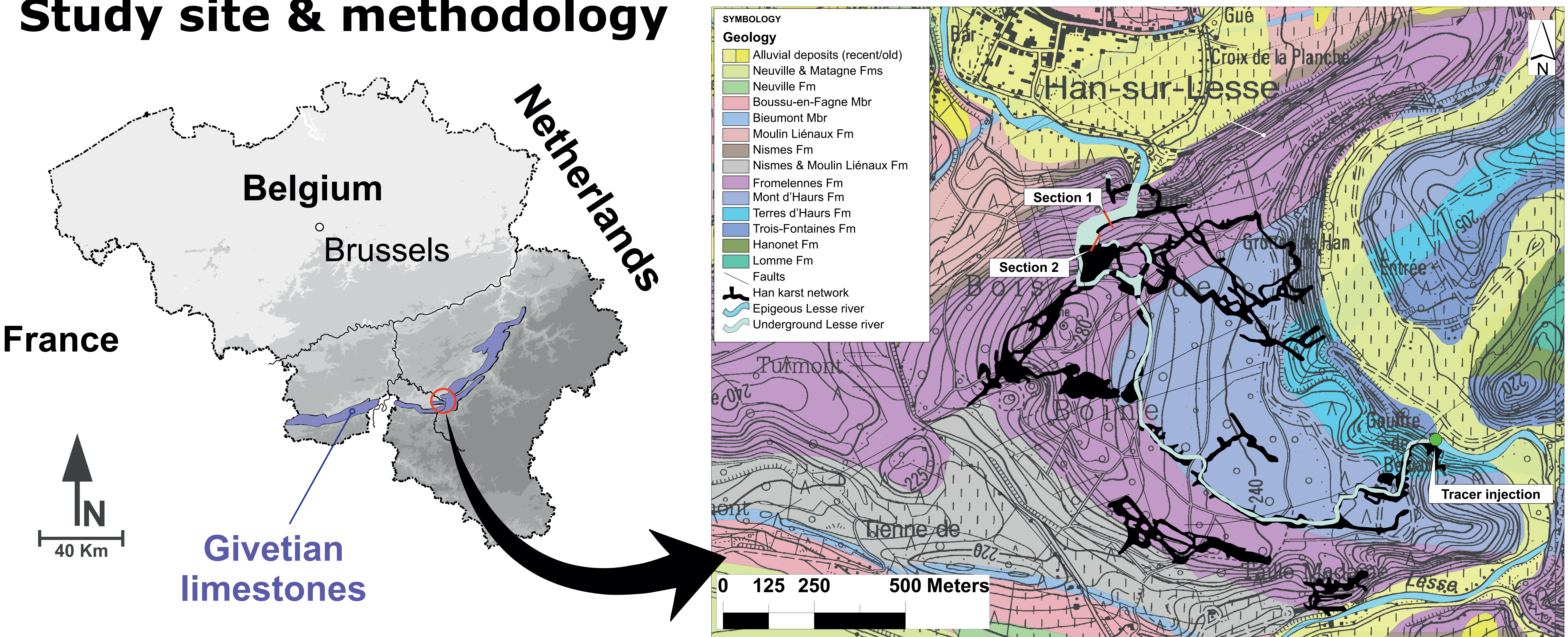
The use of compact and 100% submersible automatic fluorometers Fluo-Green (Poulain et al. 2017) opens new perspectives to investigate karst groundwater behavior with original experimentations.



Dye dispersion in karst conduits is usually supposed to be homogeneous. Most of dye tracing experiments use a single breakthrough curve from the karst spring or the accessible part of the underground river to investigate the groundwater dynamic.

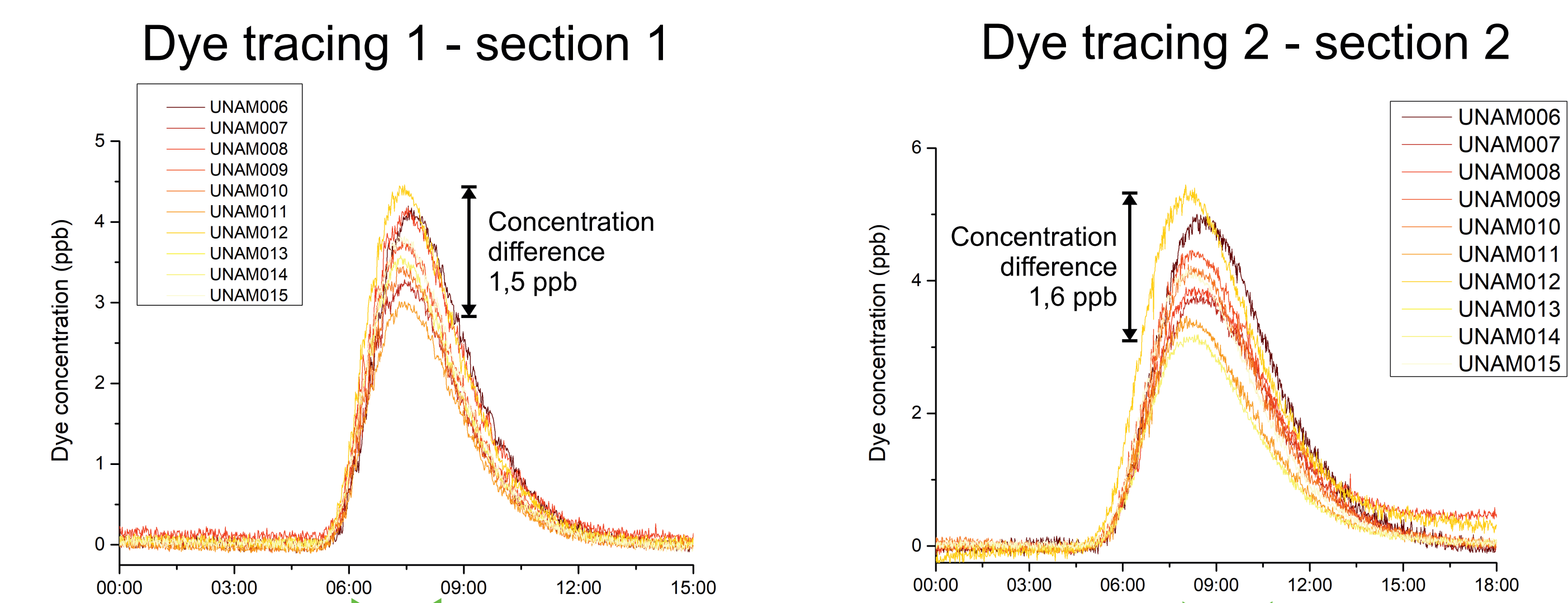
We wanted to evaluate the possible effect of karst conduits morphology on the dye behavior by mean of multiple fluorometers, measuring the spatial variability of concentration across sections of a well-known karst river.

Study site & methodology



Dye behavior in karst conduits ?

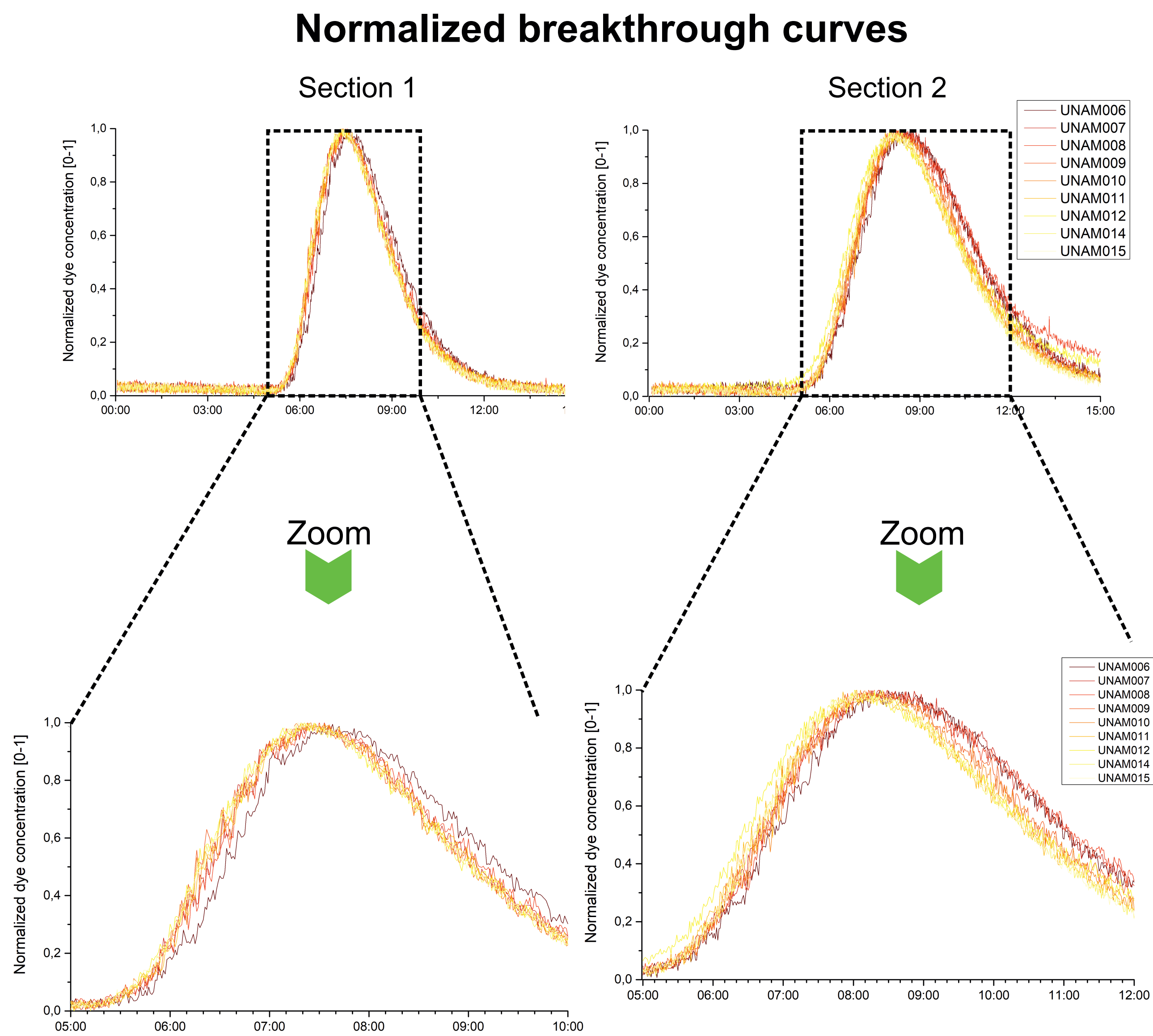
Field results



The BTC's show the same restitution behavior with an advective curve with limited dispersion and retardation.

Concentration variation between sampling points on the section is high with up to 50% differences for the peak concentration.

This show that the dispersion of the dye is not homogeneous in this karst conduit, even if the sampling point is more than 1 kilometer downstream the injection point.



When normalized on a 0 to 1 scale for dye concentration, the temporal variability is easier to observe.

For both sections, the dye peak is always observed first where current velocity is higher, with higher depths.

The flurometers in shallow water, near the riverbank where the current is slow, record delayed arrival of the dye.

The time arrival difference between the sampling points is **10 to 20 minutes** for section 1, up to **40 minutes** for section 2.

These results suggest that the lateral dispersion of the dye is not homogeneous in the underground river of the Han-sur-Lesse cave.

Lateral and depth variability in the dye concentration is observed but can not be related to any factor yet (position, current velocity, conduit morphology).

The breakthrough curves recorded after the sump (section 2) show bigger time shifts in the dye arrival than the BTC of the section 1. This indicates that the behavior of the dye into the karst conduit may change significantly on short scales.

Perspectives

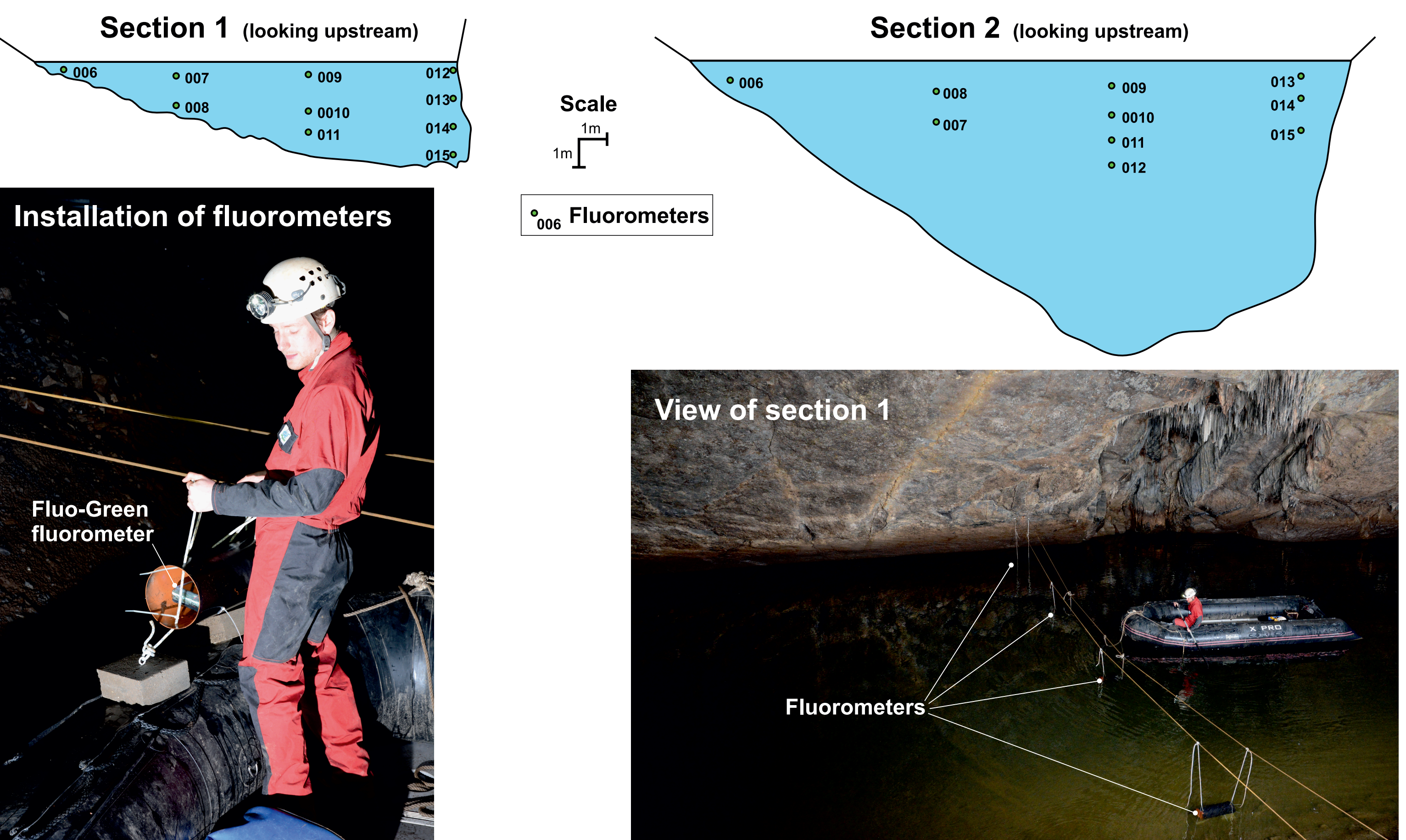
- **The first results show interesting information. Variability in both concentration and temporality may be observed on relatively simple cases in a well-known and delimited karst river.**
- **It will be useful to investigate other cases : variable conduit morphologies, high current variability, interferences with large volume of water, mixing of water from different karst conduits.**
- **We are looking for additionnal research questions and perspectives related to dye behavior or dispersion in karst (or other hydrological environment) that could be investigated with dye tracing.**
- **You have any suggestion about this research ? Please let us know !**

We perform two dye tracings in the karst system, with similar characteristics (discharge conditions, tracer mass).

During dye tracing 1, we measured the dye concentration on a straight part of the underground river with laminar flow (**section 1**), using 10 fluorometers installed in a homogeneous way across the river.

During dye tracing 2, we measured the dye concentration 150 meters upstream the first section, in a large section just downstream a major sump of the karst system (**section 2**).

The aim was to compare the results between the two sections, and also between the **10 fluorometers across each section**.



Fluo-Green automatic fluorometers were placed into 20 cm diameters PVC pipes to maintain their position during the entire experiment. The fluorometers recorded the dye concentration in groundwater and temperature with a **1 minute timestep**. All fluorometers were calibrated with the same blank water and uranine dye at the University of Namur laboratory.

Watch the video of the field work !

