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# AN INVESTIGATION OF THE FATE OF PETROLEUM CONTAMINANTS (LNAPL) UNDER FLUCTUATING GROUNDWATER TABLE LEVELS INDUCED BY CLIMATE CHANGE

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## 1. LIGHT-NON-AQUEOUS-PHASE-LIQUIDS (LNAPLs)?

- Derived from petroleum hydrocarbons (gasoline, diesel fuel...)
- Viscous liquids with a density < 1 g/cm<sup>3</sup> and a lifetime > 10 yrs
- Composition: mainly aliphatic hydrocarbons and BTEX
- 40% of soil and groundwater contaminations

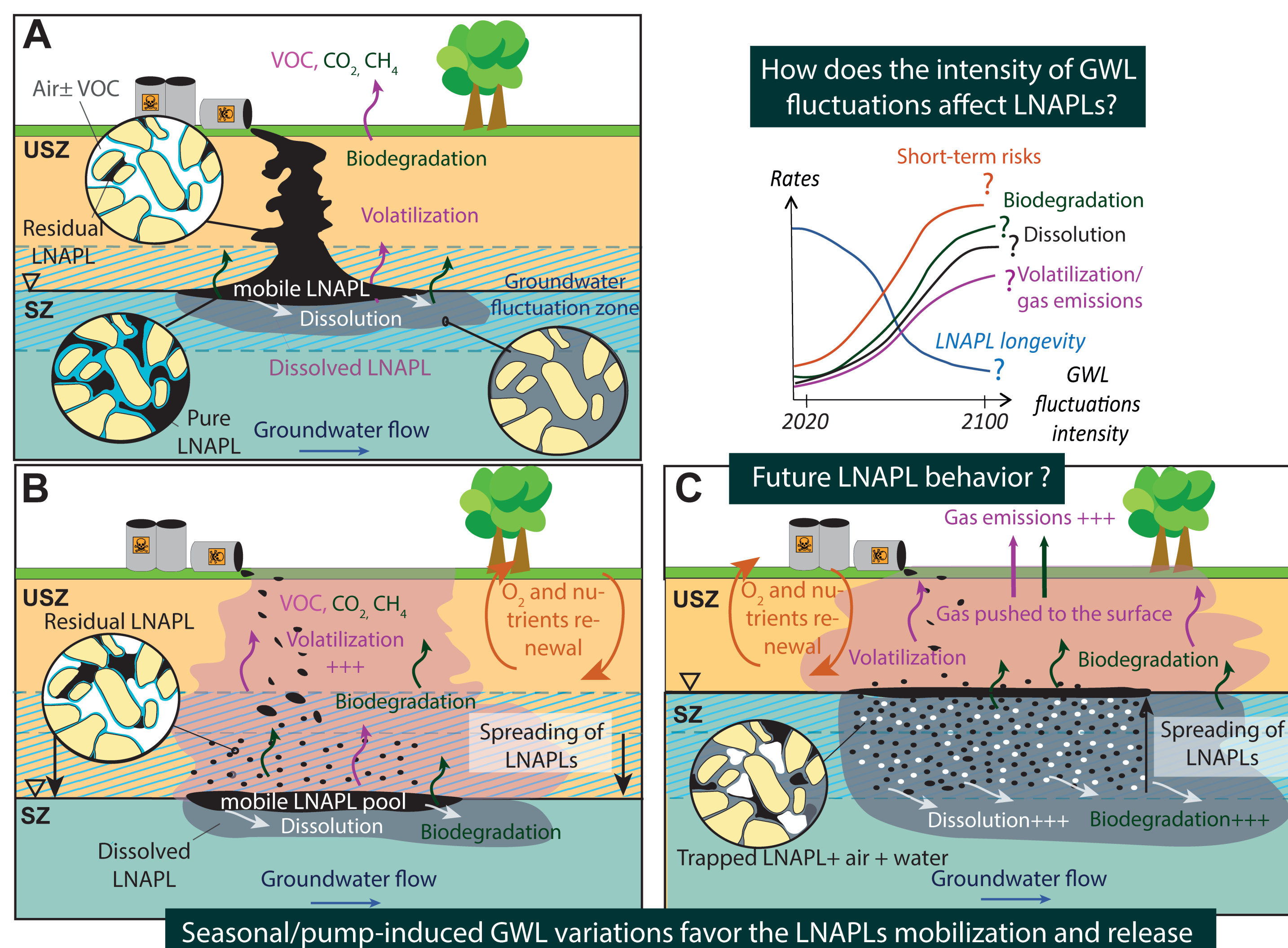


Fig. 1. Influence of the groundwater table level (GWL) fluctuations on LNAPL mobilization and release processes. (i) initial, (ii) low (dry season), (iii) high water table level (wet season). VOC: volatil organic carbon. SZ: saturated zone. USZ: unsaturated zone.

## 2. CLIMATE CHANGE, GROUNDWATER AND LNAPLs

THE PRESENCE OF GROUNDWATER TABLE FLUCTUATIONS:

- o favors the vertical spreading of the LNAPLs across the soil (Fig.1)
- o favors the release of the LNAPL compounds in the air and groundwater
- o favors the natural attenuation of the LNAPL source/ reduces the LNAPL longevity

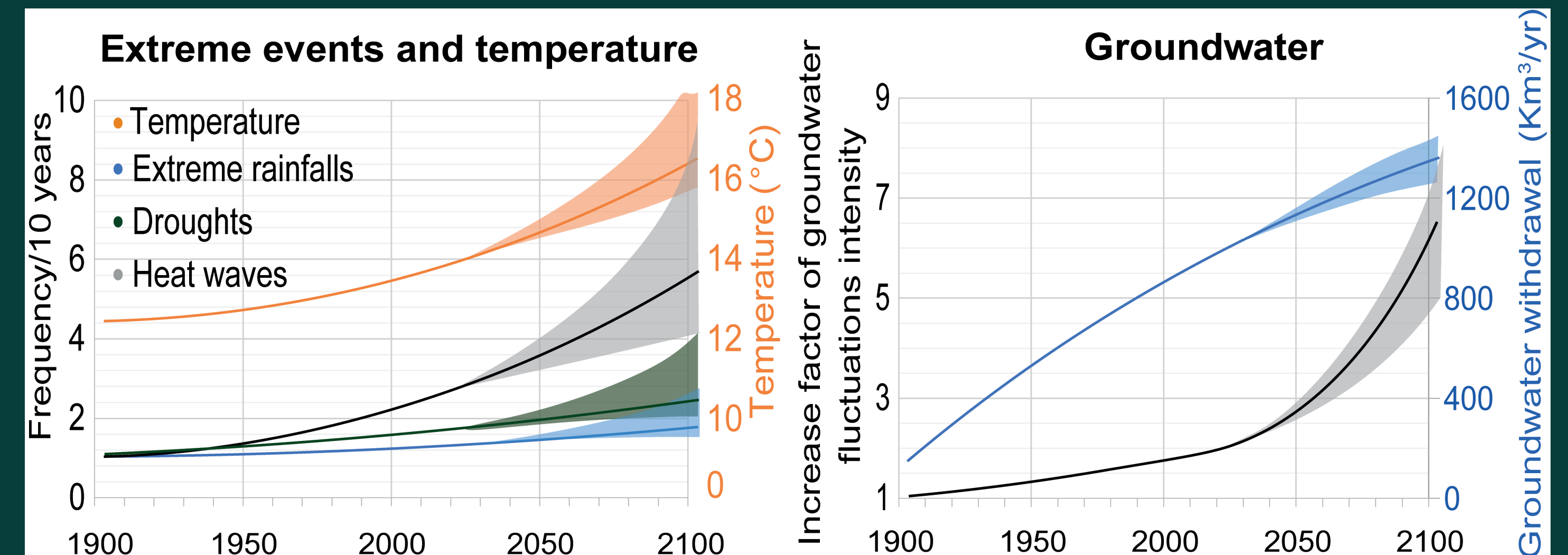


Fig. 2. Measured and projected increase of the surface temperature, extreme events frequency, groundwater withdrawal and level variations intensity from 1900 to 2100. Data from the IPCC (2021), the European Environment Agency, and Wada (2016).

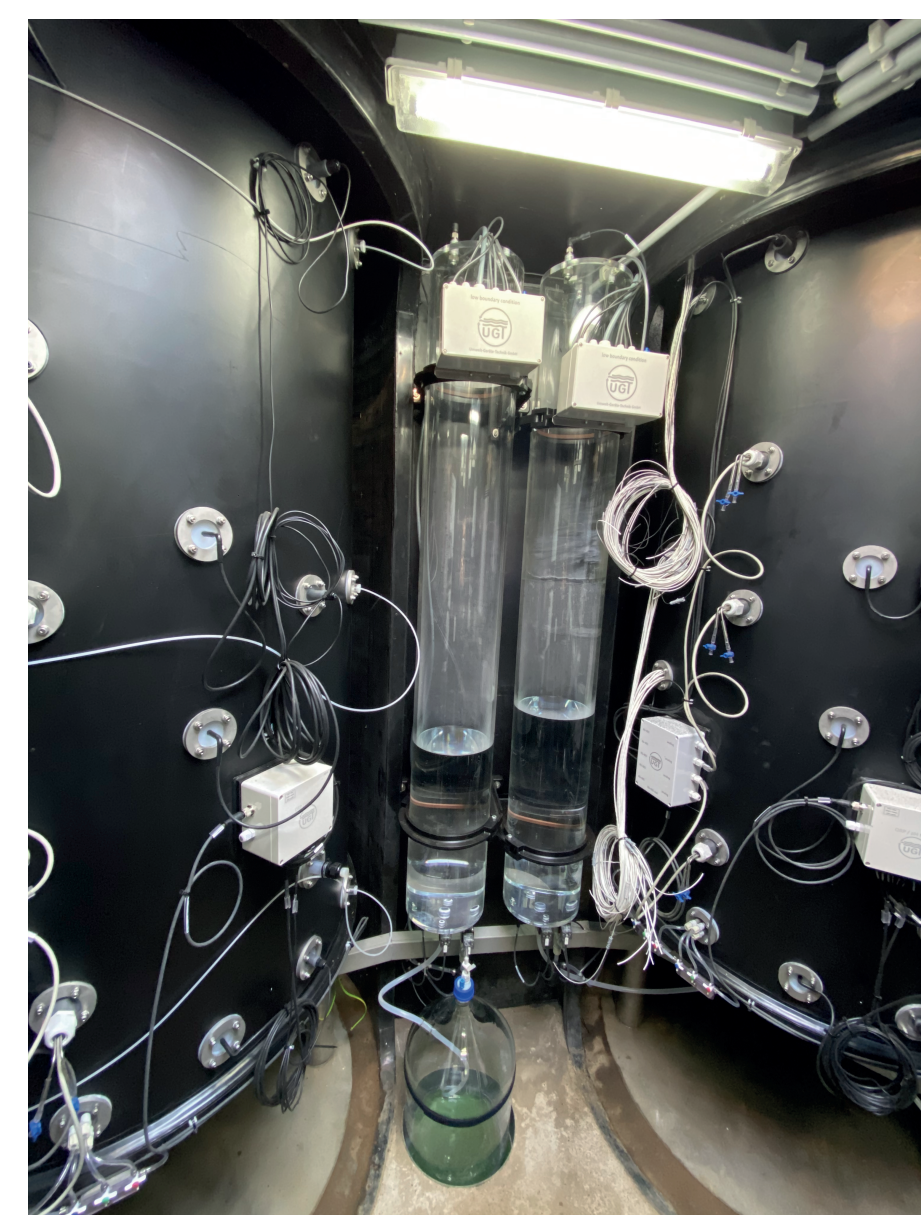
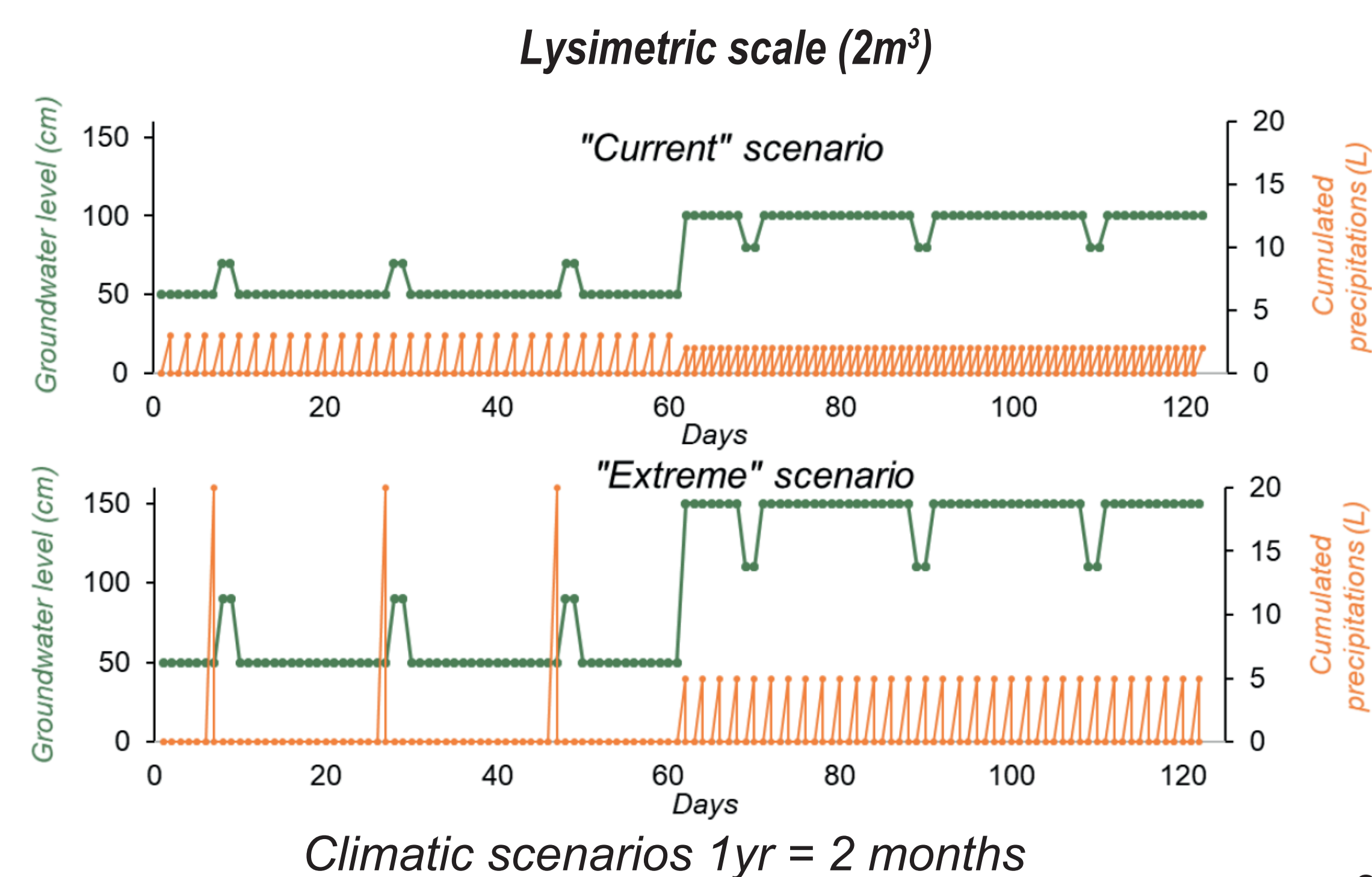
CLIMATE CHANGE MAY:

- o change precipitation and groundwater recharge intensity and frequency (Fig.2)
- o increase the intensity and frequency of the extreme climatic events.
- o increase groundwater use/decrease mean groundwater table levels.
- o increase the amplitude of seasonal and pump-induced groundwater table level variations.

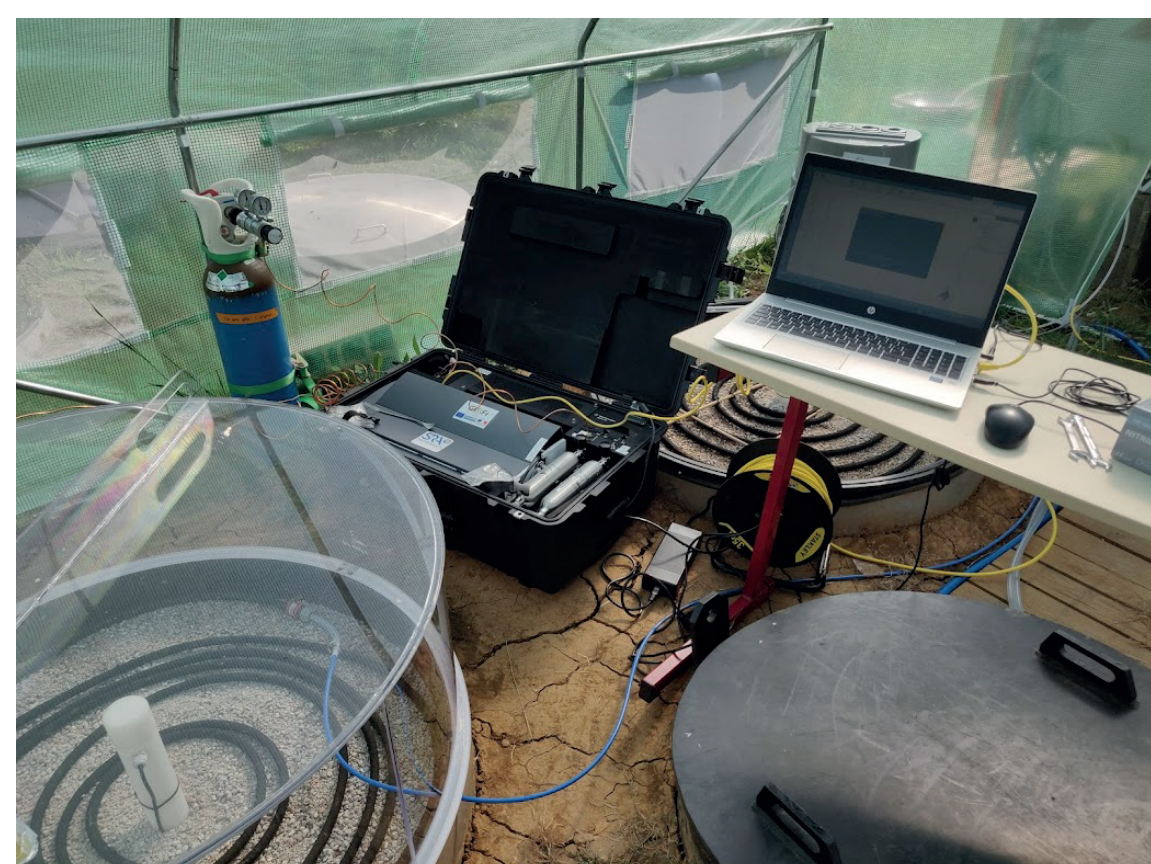
WHAT WE NEED TO KNOW:

The effect of increased groundwater level fluctuations on the LNAPLs' mobilization, release and natural attenuation rates, and the consequences for short/long-term groundwater and air quality at contaminated sites.

## 3. OUR WORK



Lysimetric columns



Gas collection chambers and μGC

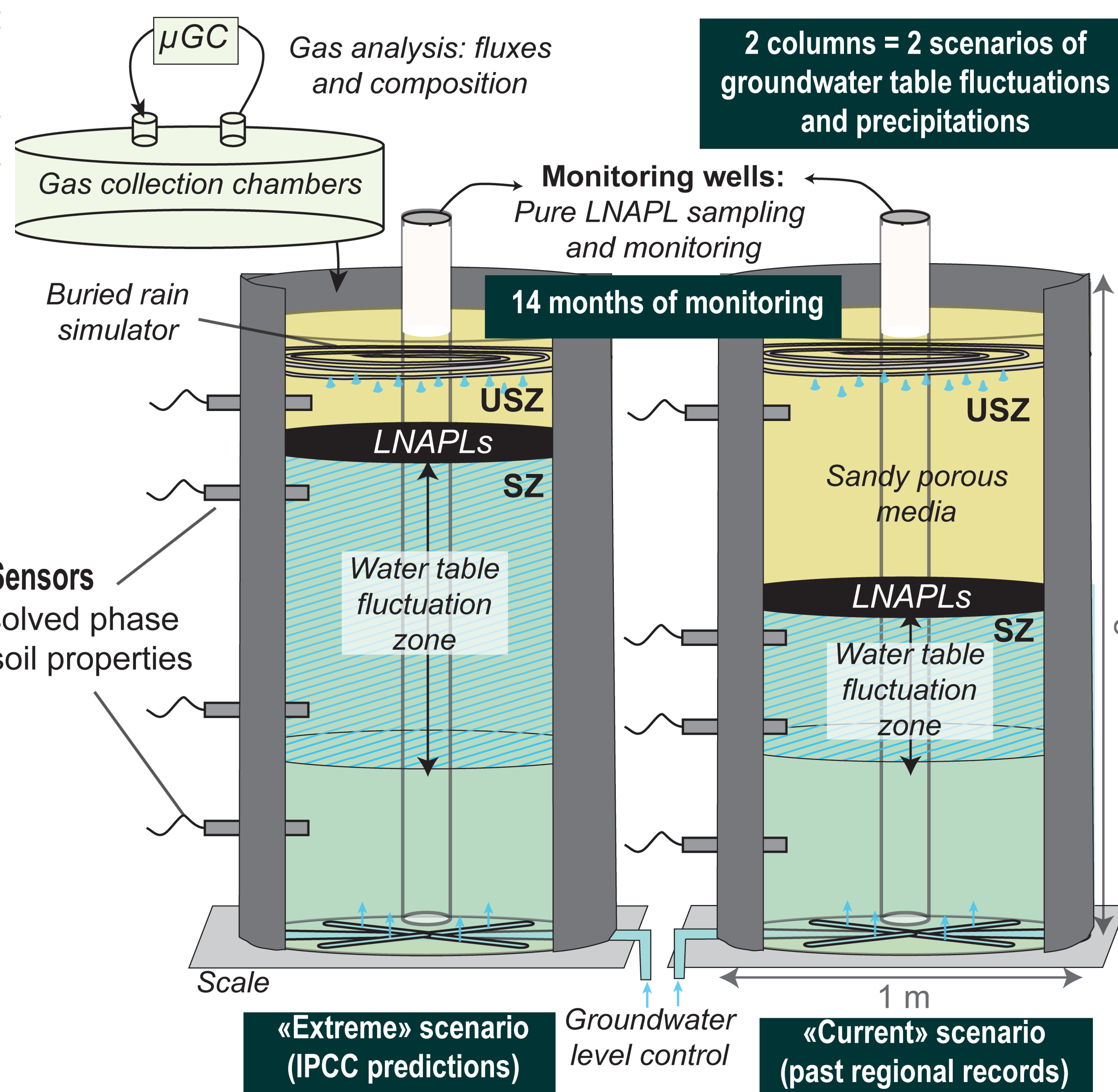
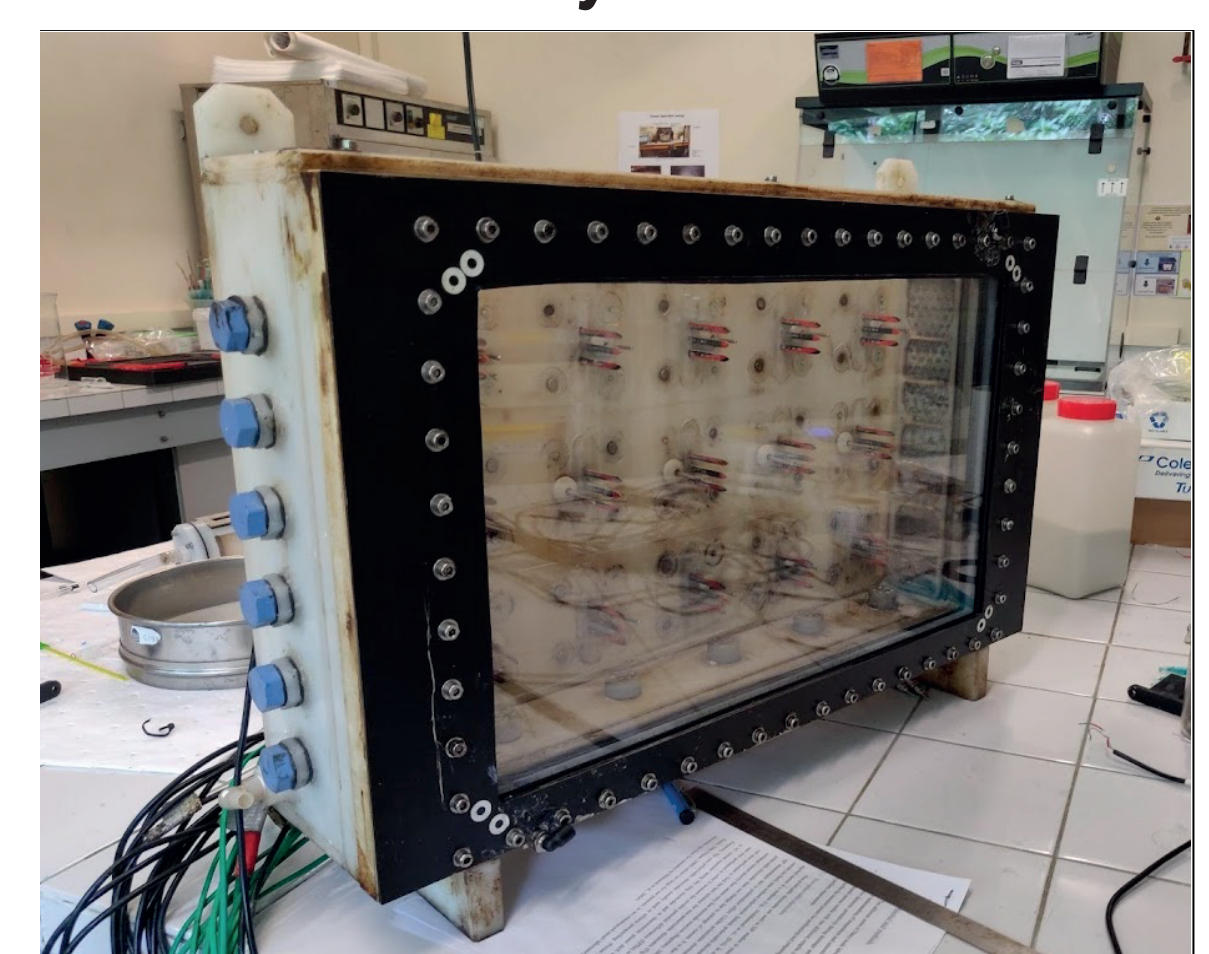


Fig. 3. Lysimetric columns (2m<sup>3</sup>) used to simulate the effect on LNAPL of two scenarios of precipitations and groundwater level variations over 14 months.

Laboratory scale



2D tanks



1D centimetric columns

THE GOALS:

- o Improve the monitoring techniques of LNAPLs contaminated sites in combining different in-situ and ex-situ monitoring techniques
- o Improve the understanding of LNAPLs behavior under various climatic conditions (current or future)

WHAT WE MONITOR?

- o Gaseous surface emissions (flux, composition, μGC)
- o The LNAPL saturation distribution in soil (electrical resistivity and permittivity)
- o Other soil physical-chemical properties (pH, RedOx, water tension, temperature)
- o The concentration and composition of the dissolved LNAPL phase (suction cups, SPE, GC/MS, TPH, DOC, FTIR)

IN THE LABORATORY:

- o Calibrations of in-situ signals (tensiometers, permittivity, resistivity) under controlled saturations of LNAPL/water/air (2 tanks/1D columns)
- o Numerical modeling of the LNAPL transport and mobilization.
- o Optimization of analytical protocols for contaminated water samples.

IN THE COMING MONTHS:

- o Application in field for the real-time monitoring of a contaminated site.
- o Upscaling of modelisation at the field scale for prediction of climate change effects on the fate of LNAPL contaminated sites.