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Lysimetric experiments to characterize the multiphase mobilization of LNAPL in contaminated soils by a multi-method monitoring approach under controlled climatic scenarios.

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What are Light -Non-Aqueous Phase Liquids (LNAPLs)?

- o Light petroleum hydrocarbons (gasoline, diesel fuel...), density < 0.85 g/cm³
- o Main composition: 75% aliphatic hydrocarbons, 25% of aromatics (BTEX).
- o 40% of soil and groundwater contamination in Europe (MTES, 2018).



Climate change and groundwater resources

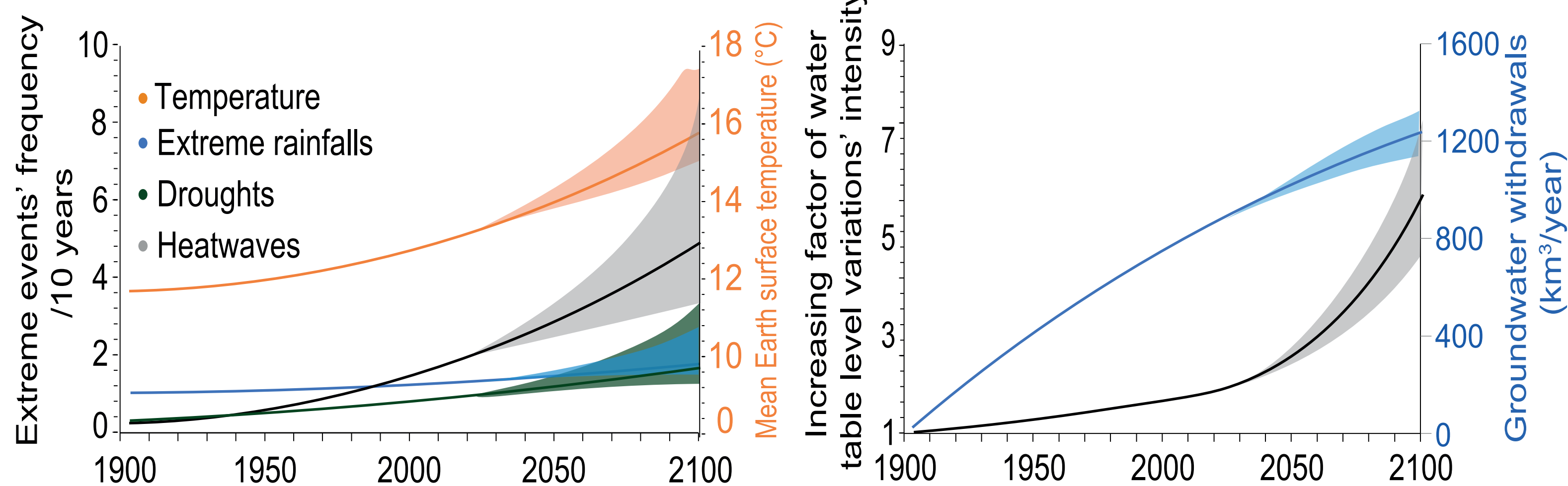


Fig.2. Measured and projected changes in average land surface temperature, intensity and frequency of extreme climate events, groundwater withdrawal and groundwater level variations' intensity from 1900 to 2100 (IPCC 2021; EEA 2021; Wada 2016).

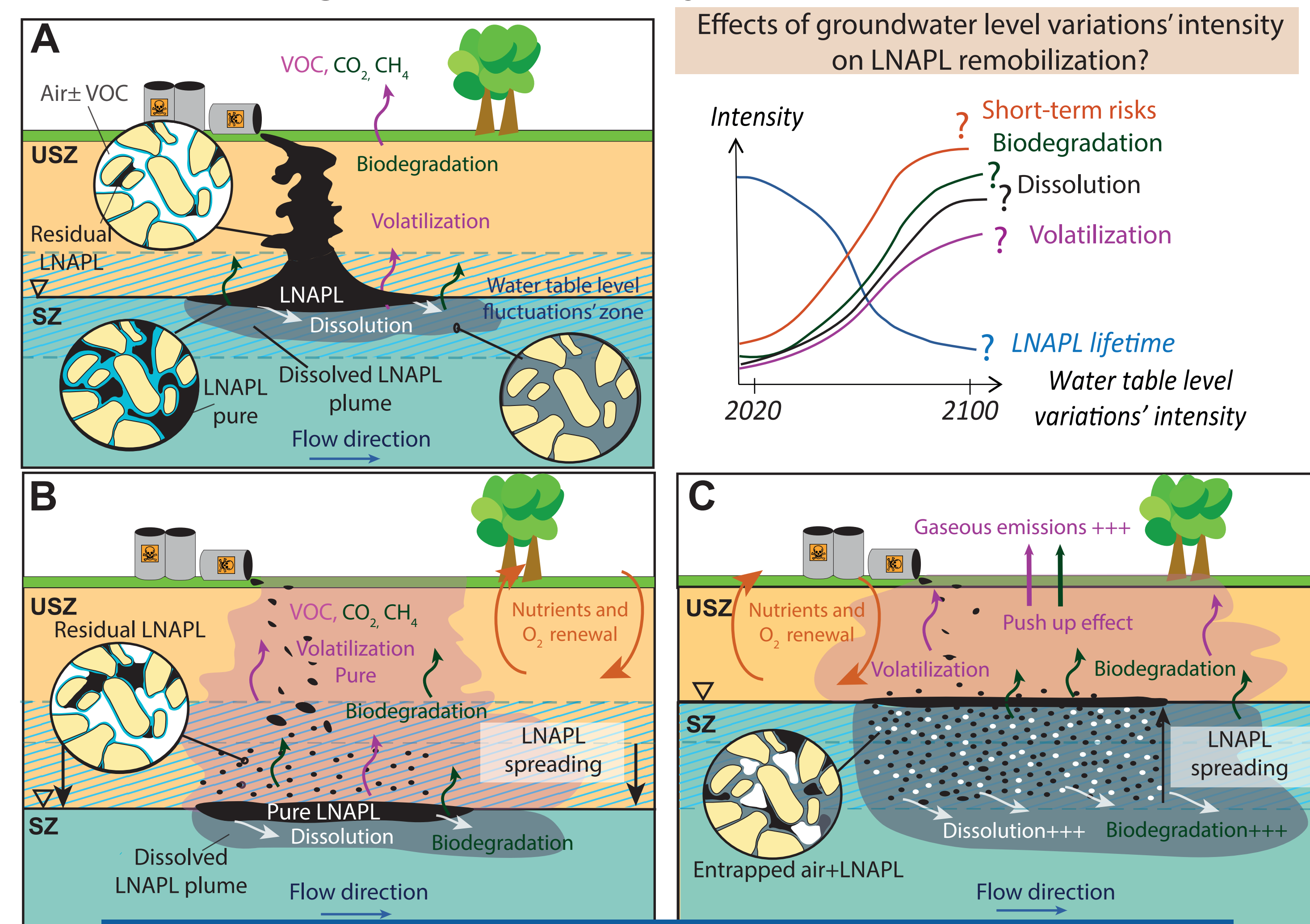
Climate change is likely to :

- o increase the intensity and frequency of extreme climatic events (Fig.2).
 - o increase groundwater consumption and decrease mean groundwater levels.
 - o change the seasonal groundwater recharge's dynamics.
 - o increase the intensity of seasonal and pump-induced groundwater level variations;
- => **What consequences for the fate of LNAPLs and their environmental impacts?**

The project aims to:

- o Better understand/predict the LNAPLs' behaviour under different scenarios of rainfalls and intensities of water table level fluctuations.
- o Improve in-situ and ex-situ monitoring techniques for LNAPL-contaminated sites.

Influence of the groundwater level dynamic on LNAPLs' remobilization



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

The presence of seasonal (or pump-induced) water table level variations:

- o favors the LNAPL spreading and trapping throughout the soil porosity (Fig.1).
- o promotes the LNAPL release to the water table and the atmosphere.
- o promotes natural attenuation and decreases the LNAPL source's longevity
- o **What effect of the groundwater level variations' intensity on the LNAPL fate?**

Experimental approach

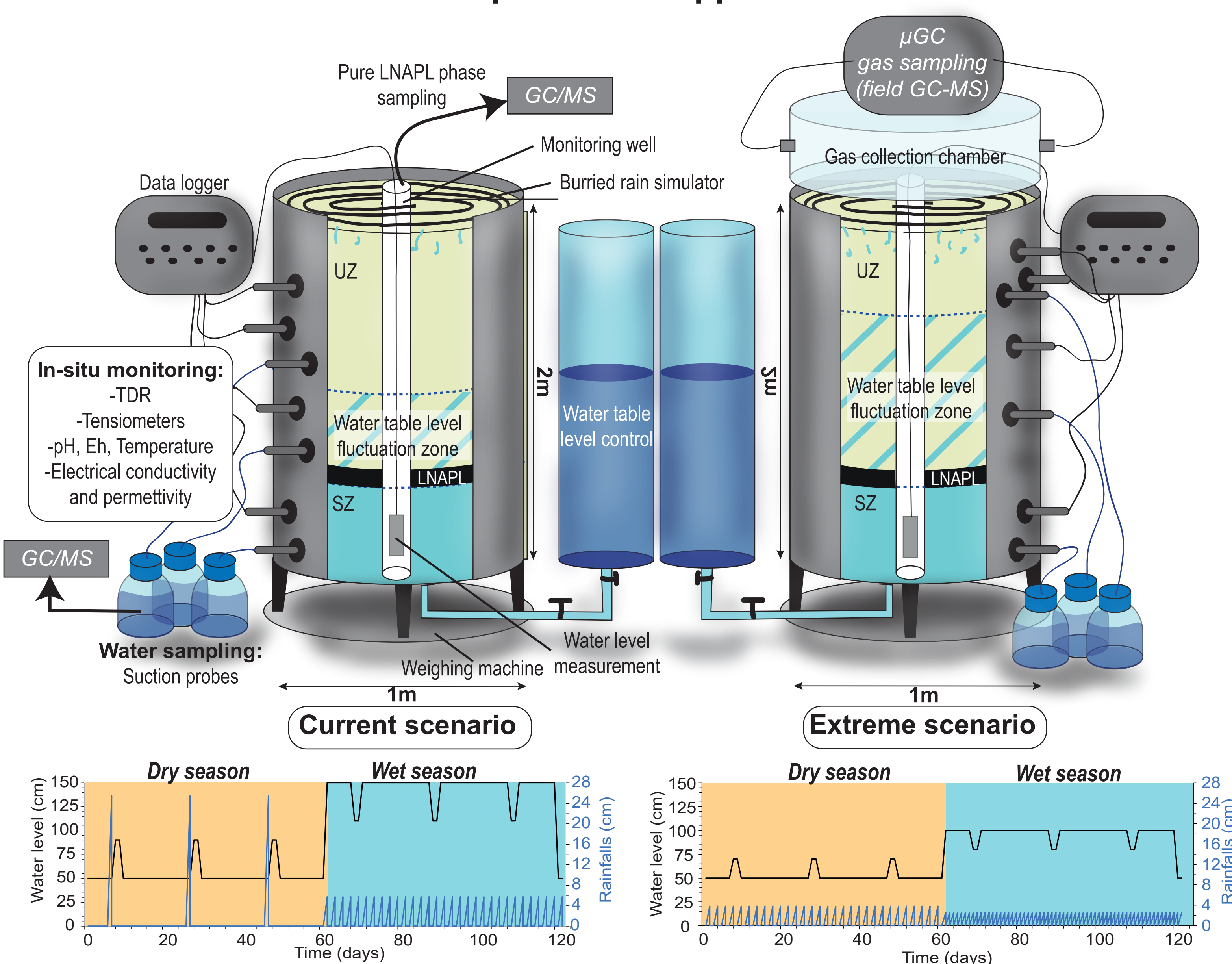
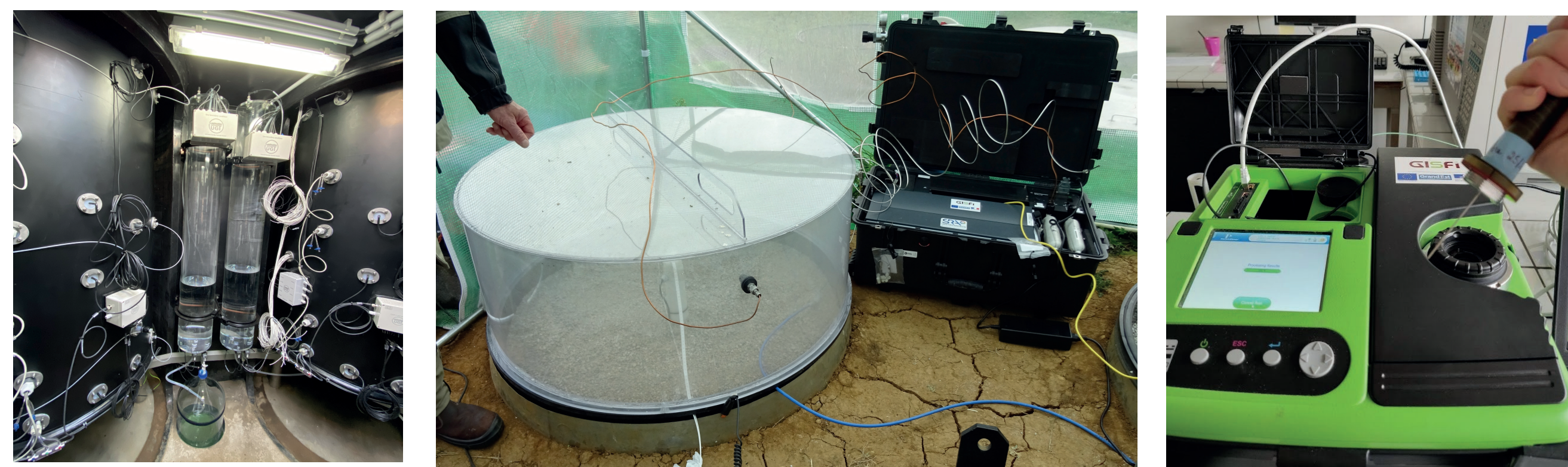


Fig. 3. Experimental device used (GISFI, Homécourt, France) to monitor the effect of two scenarios (current and extreme) of rainfalls and water table level variations' intensity on a LNAPL-contaminated (50L) soil during 120 days



Work in progress:

- o Controlled scenarios of temperature
- o Field monitoring
- o Numerical modelization of LNAPL transfert and remobilization processes.
- o Calibration of electrical dielectric permittivity as a function of the LNAPL soil saturation.

Some of the results obtained

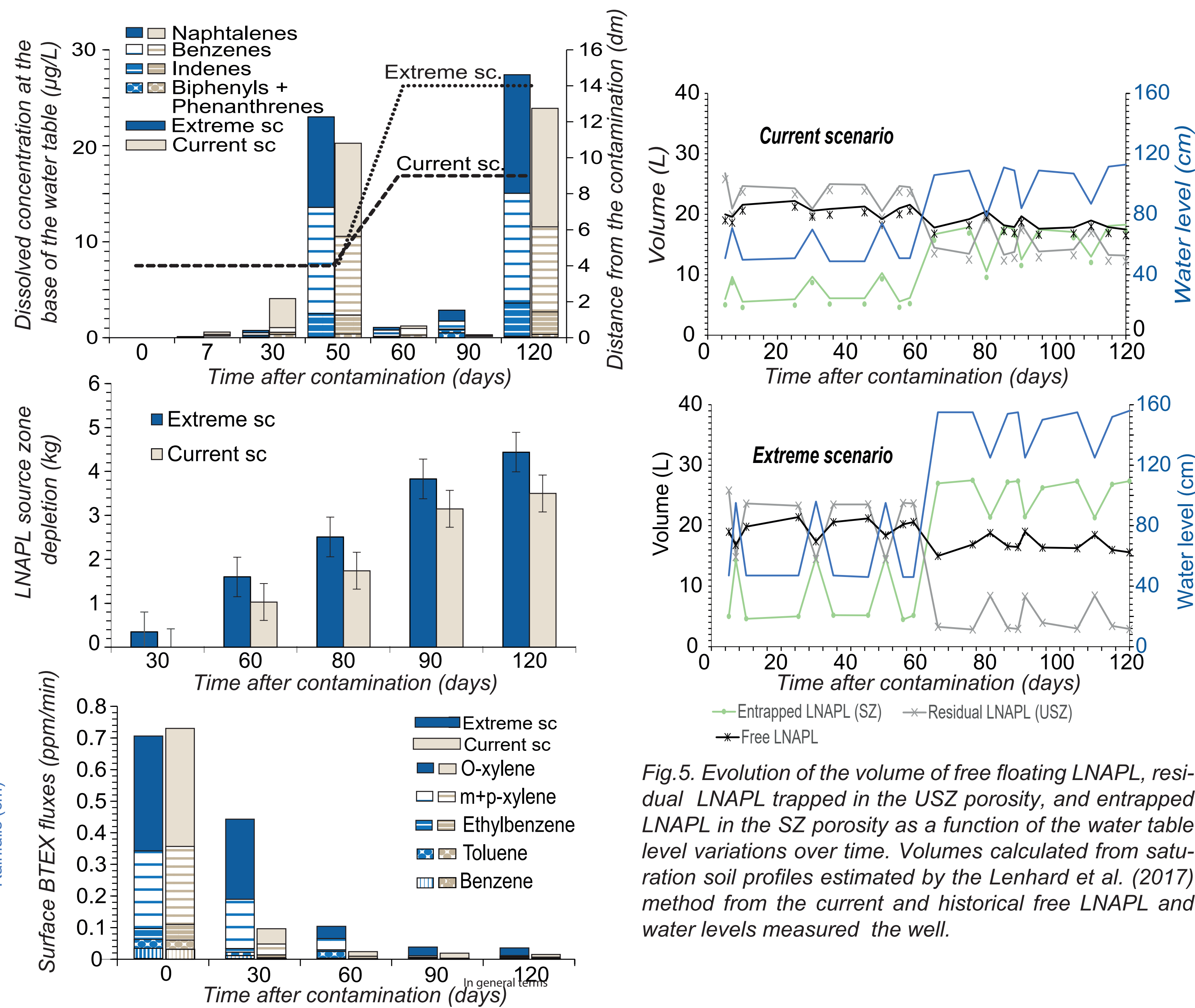


Fig. 4. Dissolved LNAPL concentrations, surface BTEX fluxes and LNAPL source zone depletion with time.

The main results and conclusions are:

- o Fluctuating groundwater levels cause continuous dilution and reconcentration of the dissolved LNAPL phase at the base of the water table with time (Fig.4).
- o A depletion of the LNAPL source of 9% (current scenario) and 11.7% (extreme scenario) mainly due to dissolution and biodegradation was observed after 120 days.
- o Surface gas fluxes decreases sharply over time and permitted the loss of only few grams.

Increasing the water table level fluctuations' intensity and extreme rainfalls lead to:

- o Enhanced LNAPL spreading and trapping in soil and thus, increased water table/LNAPL and air/LNAPL contact surfaces (Fig.5).
- o Increased volatilization rates and surface gas emissions (Fig.4).
- o Increased dissolution rates and dissolved LNAPL concentrations (Fig.4)
- o **Greater short-term impacts on the air and water quality at contaminated sites.**
- o **Higher LNAPL source attenuation rates and decreased contamination lifetime.**