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An innovative membrane-based sensor technology for large-scale measurements of gas concentrations in the subsurface

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There is a large discrepancy between the spatial extent of a catchment and the volume or area covered by a single sensor, particularly for sensors operating below the soil surface. Especially in the unsaturated zone, spatial heterogeneity combined with the very small soil volume represented by a data point (often 1 cubic decimeter or less), this contrast necessitates vast sensor networks that are costly to maintain and generate large quantities of data that require extensive processing to provide information useful at scales relevant for land and water management.

Over the past years, we developed a technology to measure the concentration of selected gases in soils by burying gas-permeable, flexible tubes of up to tens of meters of length in the soil at desired depths and flushing them with a gas of known composition (e.g., dry air). Pressure changes observed during short intervals during which the gas flow is stopped can be used to derive the difference in partial pressures of a target gas inside the tube and in the soil surrounding the tube. After processing, this gives the average concentration of the target gas in the soil surrounding the entire length of the tube. The technology is operational for CO_2, and will be employed in a forest ecosystem to measure soil respiration in real time.

By specific choices of the tube material, the composition of the flushing gas, and the reference system, the measurement system can be adapted to other gases. If the target gas is water vapor, the relative humidity (RH) of soil air can be measured. According to first laboratory results this results in a measure of the area-averaged soil water content assuming local phase equilibrium between water vapor and liquid soil water. In very dry soil, e.g., in arid and hyper-arid regions, the RH of the soil air drops measurably. In this case the averaged matric potential of the soil water can be monitored *in situ* in a range far beyond that of water-filled tensiometers.

The presentation will explain the set-up of the system, showcase completed trials and elaborate on on-going plans for CO_2-concentration measurements in a forest soil.