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Groundwater recharge estimates combining soil isotope profiles and classical soil water monitoring techniques

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To improve knowledge of hydrological and hydrogeological flow processes and their dependency on climate conditions it is becoming increasingly important to integrate sensors technology, independent observation methods, and new modeling techniques. Established isotope methods are usually regarded as a supplement and extension to classical hydrological investigation methods but are rarely included in soil water balance models. However, the combination could close knowledge gaps and thus lead to more precise and realistic predictions and therefore to better water management. Within the Wasserpfad project, a project of the Department of Civil Engineering at the TH Lübeck, soil moisture has been measured since May 2018. SMT100 soil moisture sensors from TRUEBNER GmbH are used at depths of 20, 40, 60, and 80 cm. Next to the station a 2m deep soil profile was taken in 2020, to estimate groundwater recharge using stable isotope equilibration methods and cryogenic extraction combined with soil water balance modeling. Vertical profiles of stable isotopes have been determined with a 10-cm resolution and measured with Tunable Diode Laser spectrometry. Percolation through the soil profile has been estimated based on the convolution of a seasonal input function using advection-dispersion transport models. Percolation rate estimate based on environmental isotope profiles results in 230 mm per year. Fitting of the advection-dispersion equation using a sinusoidal isotope input fitted to available time series provides an estimate of 255 mm per year. This difference is due to the dispersion effect on the isotope minima and maxima. The result of modeling the soil moisture data with a soil water balance model integrating the Richards equation for water transport and Penmen-Monteith based calculation of actual evaporation is used to verify the percolation rates. The analysis of soil moisture and isotope data by modeling provides a direct and efficient way to estimate the percolation rate. The combination of isotope methods with classical hydrological measuring techniques offers the possibility to verify results, to calibrate models, or to investigate the limits of isotope methods. Thus, flow processes can be predicted more reliably in the future.