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Behavior of water balance components at sites with shallow groundwater tables: Possibilities and limitations of their simulation using different types of groundwater lysimeters

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Groundwater lysimeters are a special type of lysimeter that can provide valuable insights into processes occurring at sites with shallow groundwater tables. Typically, water balance simulations for such sites using hydrological models are complicated by the permanently changing directions of the water fluxes due to percolation and capillary rise and the complex hydrological conditions. Problems also arise when trying to imitate such conditions correctly in a lysimeter. The biggest challenge is to realistically simulate the lower boundary condition, which has a pronounced impact on most of the hydrological variables, especially when considering time scales shorter than one day.

Historically, groundwater levels in soil monoliths of groundwater lysimeters were controlled by so-called Mariotte bottles (type 1). Even nowadays, most groundwater lysimeters use such systems. From a technical standpoint, the solution is reliable and simple to operate and maintain. Nevertheless, the accuracy of Mariotte bottles (type 1) is limited when simulatingnatural shallow groundwater table conditions which are characterized by fluctuations on a short time scale. Today's lysimeters are able to simulate measured groundwater levels with higher accuracy, even for short time steps (type 2). However, conditions in the lysimeter and the place where the reference groundwater level is measured have to be consistent in order to get reliable results. Problems also arise if the behavior of the groundwater level itself is the aim of the investigation as the groundwater level has to be pre-defined, i.e. it is the control value. A new approach regulates the lower boundary condition by controlling the in- and outflows of the lysimeter (type 3). This enlarges the field of possible applications of groundwater lysimeters, especially with respect to simulations of natural site conditions and short time scales.

The presentation compares the performance of different types of groundwater lysimeters with respect to simulations of the typical diurnal behavior of water balance variables at sites with shallow groundwater tables. It will be shown that lysimeters controlled by Mariotte bottles (type 1) have problems to reflect the diurnal character of the groundwater level and the in-/outflow appropriately. Furthermore, we will demonstrate the possibilities of using a groundwater level controlled lysimeter (type 2) to imitate the diurnal behavior of water balance variables for cases where the site conditions of the reference place and those of the lysimeter match and for cases where they are different. Finally, the behavior of water balance variables of a groundwater lysimeter controlled by the in/outflow (type 3) will show that this method can be a better alternative to type 2 lysimeters when the groundwater level development itself is in the focus of the investigation.