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# Evaluating lysimeter drainage against soil deep percolation modeled with profile soil moisture and lab measured hydraulic properties

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## Introduction

- Quantifying recharge via deep percolation is needed for sustainable management of water resources
- The impact of climate change on recharge can be addressed with robust modeled predictions
- Combining different techniques for in situ determination of soil deep percolation can reduce the uncertainties on water balance

## Research questions

- Can soil water flow modeling based on lab measured hydraulic properties replicate field measurements of profile soil moisture?
- Is there enough information in soil texture and profile soil water content time series to estimate soil unsaturated flow?
- How big is the difference in estimated annual recharge between lysimeters, inverse modeling of profile soil moisture and texture **(SWC METHOD)**, and forward modeling based on lab measured hydraulic properties **(LAB METHOD)**?

## Materials and methods

### The 1D soil water flow model

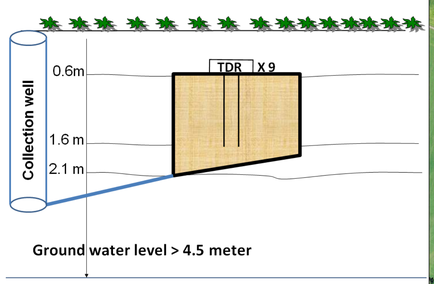
- Hydrus 1D based on Richards equation and the Mualem (1976) van Genuchten (1980) model
- Inverse optimization of soil hydraulic parameters $\alpha$, $K_{sat}$ with profile soil moisture time series, texture and atmospheric (transient) boundary conditions. All other parameters kept constant to the default textural values available in Hydrus 1D.

### Measurements

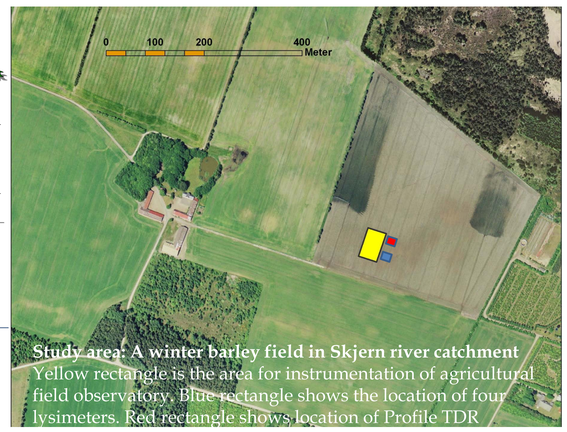
- Lab determination of water retention curve, Ksat and K(h) with drip infiltrometer on large intact soil cores (20x20cm)
- Automated large (12.5 m$^2$) zero tension lysimeters located below the root zone.
- Automated profile TDR measurements for below root zone observations of soil moisture; capacitance probes for higher depth resolution near the surface

### Field instrumentation

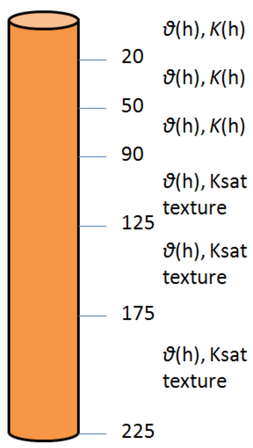
**Deep percolation lysimeter**




**Four 12.5m² repacked lysimeters**



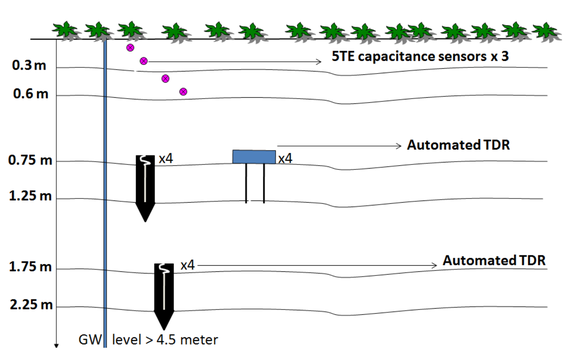

Study area: A winter barley field in Skjern river catchment
Yellow rectangle is the area for instrumentation of agricultural field observatory. Blue rectangle shows the location of four lysimeters. Red rectangle shows location of Profile TDR



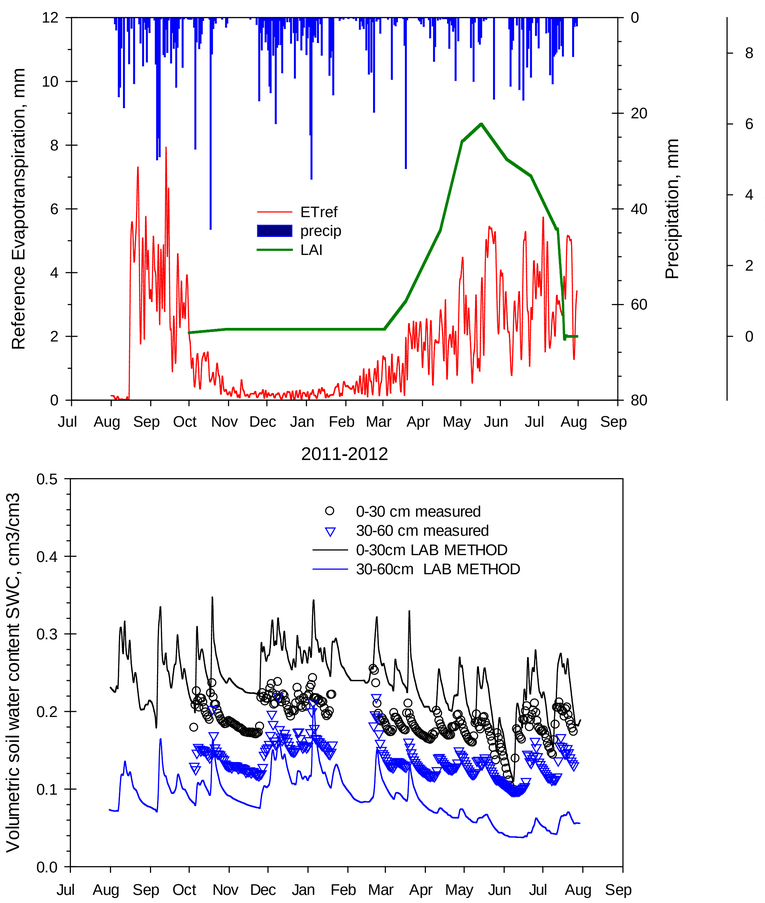

**Lab measured hydraulic properties undisturbed soil cores**

8 rod + 4 std TDR
12 5TE sensors

**Automated Profile Soil Moisture Layout**

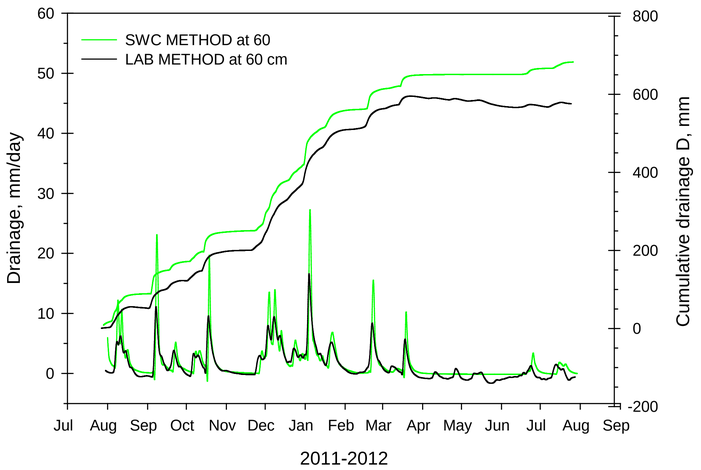



### Upper boundary and root zone

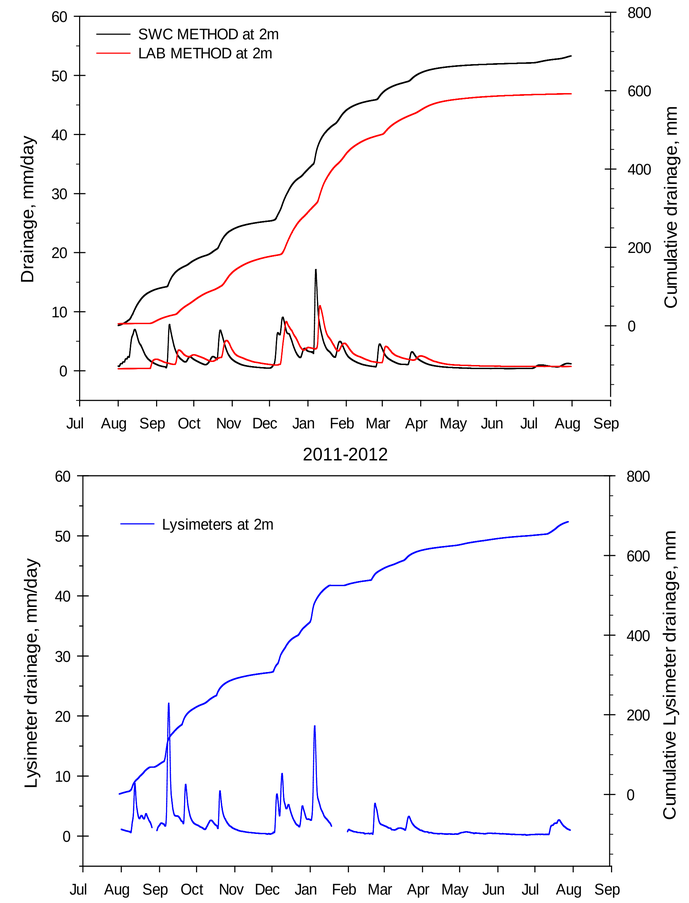






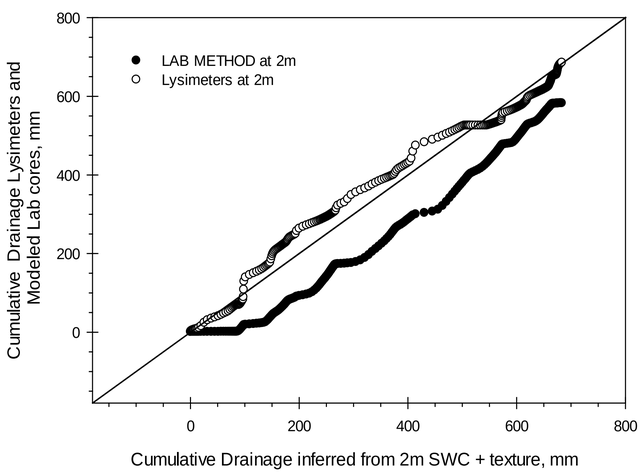



### Below root zone field, lysimeters










## Highlights

- Near surface soil moisture is overestimated (0-30cm) and underestimated (30-60cm) by LAB METHOD, but the overall dynamics are well represented
- Annual recharge estimated at 60 cm and 2m depth with SWC METHOD was 17 and 20% (100-120 mm) higher than LAB METHOD, probably due to uncertainty in estimation of $K_{sat}$ from texture.
- Annual recharge from lysimeters and SWC METHOD (2m depth) is in good agreement (< 5mm), however; lysimeters yield higher flow rates during high precipitation
- In general, recharge from LAB METHOD was 17% lower than lysimeters and SWC METHOD. This is probably an indication that even in sand soils (>90% sand), differences between repacked soils (SWC METHOD and Lysimeters) and undisturbed soils (intact soil cores-LAB METHOD) have a large impact on the estimated recharge
- Good agreement between lysimeters and SWC METHOD exist, validating the use of this method for upscaling ground water recharge

## Conclusions

- Soil moisture time series and soil texture information can be used effectively to predict ground water recharge
- In situ soil moisture dynamics was well represented by lab hydraulic property cores, however, the magnitude of soil moisture measurements was not
- Annual recharge with a combination of independent methods had an uncertainty of ±10%

## References

Mualem Y. (1976) New Model for Predicting Hydraulic Conductivity of Unsaturated Porous-Media. Water Resources Research 12:513-522.
Simunek J., van Genuchten M.T., Sejna M. (2008) Development and applications of the HYDRUS and STANMOD software packages and related codes. Vadose Zone Journal 7:587-600.
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