Projektträger: PtJ Projektträger Jülich Forschungszentrum Jülich
FZW Forschungszentrum Waldökosysteme
BEST Bioenergie-Regionen stärken
GEORG-AUGUST-UNIVERSITÄT GÖTTINGEN
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On the water budget of short rotation coppices

Using WaSim-ETH to derive ground water recharge of short rotation coppices

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Project aims

The European Union has committed to increase the proportion of renewable energy from 9% in 2010 to 20% of total energy consumption in 2020; the scope for Germany is actually 35%. Short rotation coppices (SRC) with mainly poplar and willow trees provide a high potential of energy supply and enable the substitution of fossil fuels. One negative effect that comes along with the establishment of SRC is a reduced groundwater recharge, as higher rates of transpiration and interception evaporation of poplar and willow plantations can be expected. Therefore it is very important to measure, analyze, and model the effects of SRC-planting on landscape water budgets, which are important aims of the BEST -joint research project. To compare different regions, a landscape model approach, using the hydrological model system WaSim-ETH, was set up to derive water budgets including other land uses like forests, pastures, and annual crops.

Measurement level

To derive model sensitive parameters like the seasonal development of leaf area index (LAI) and stomata resistance for the land use SRC, measurements were made on research plots. Furthermore soil hydrological properties are measured to validate the model at plot site.

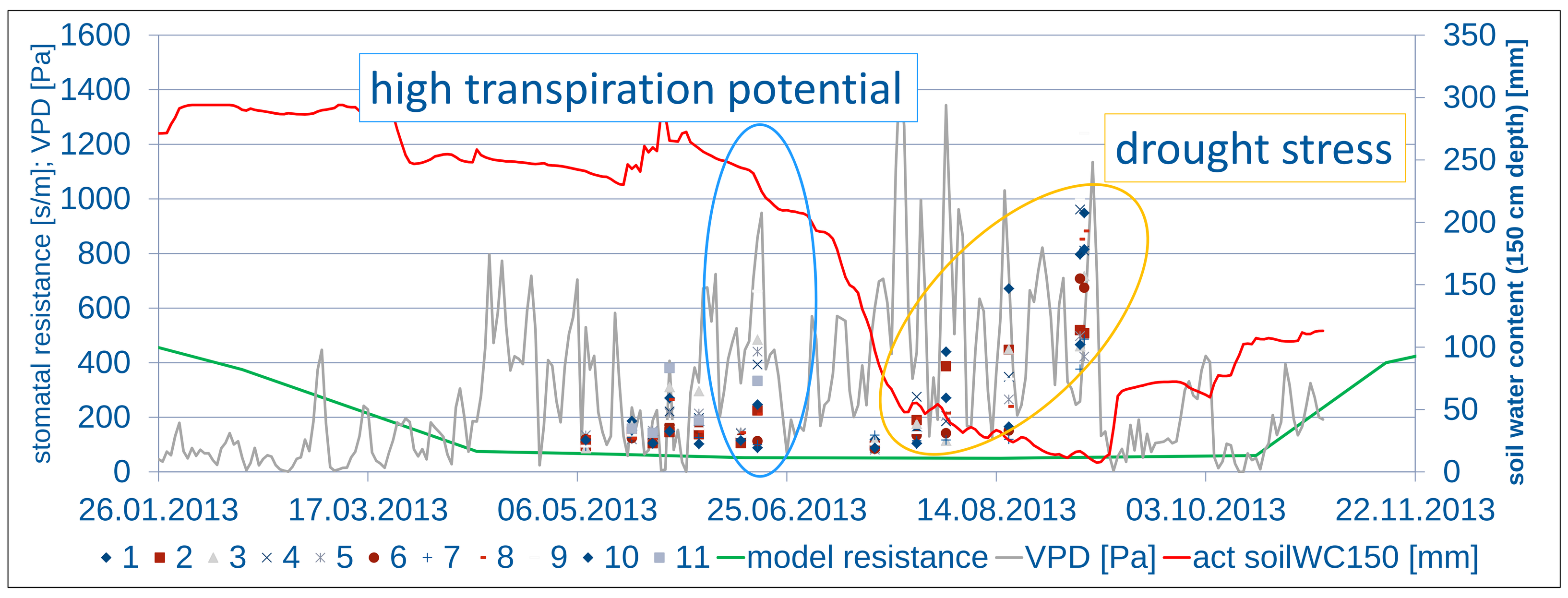

Fig. 1: seasonal development of measured stomata resistance using a Leaf Porometer SC-1 from Decagon Devices. Weekly measurements at 11 plots, if weather conditions are suitable.

Figure 1 shows, that the low **STOMATAL RESISTANCES** that had to be used for parameterization in the model could be confirmed by measurements. Furthermore the influence of abiotic factors like atmospheric forcing and soil water availability on the measurements is shown.

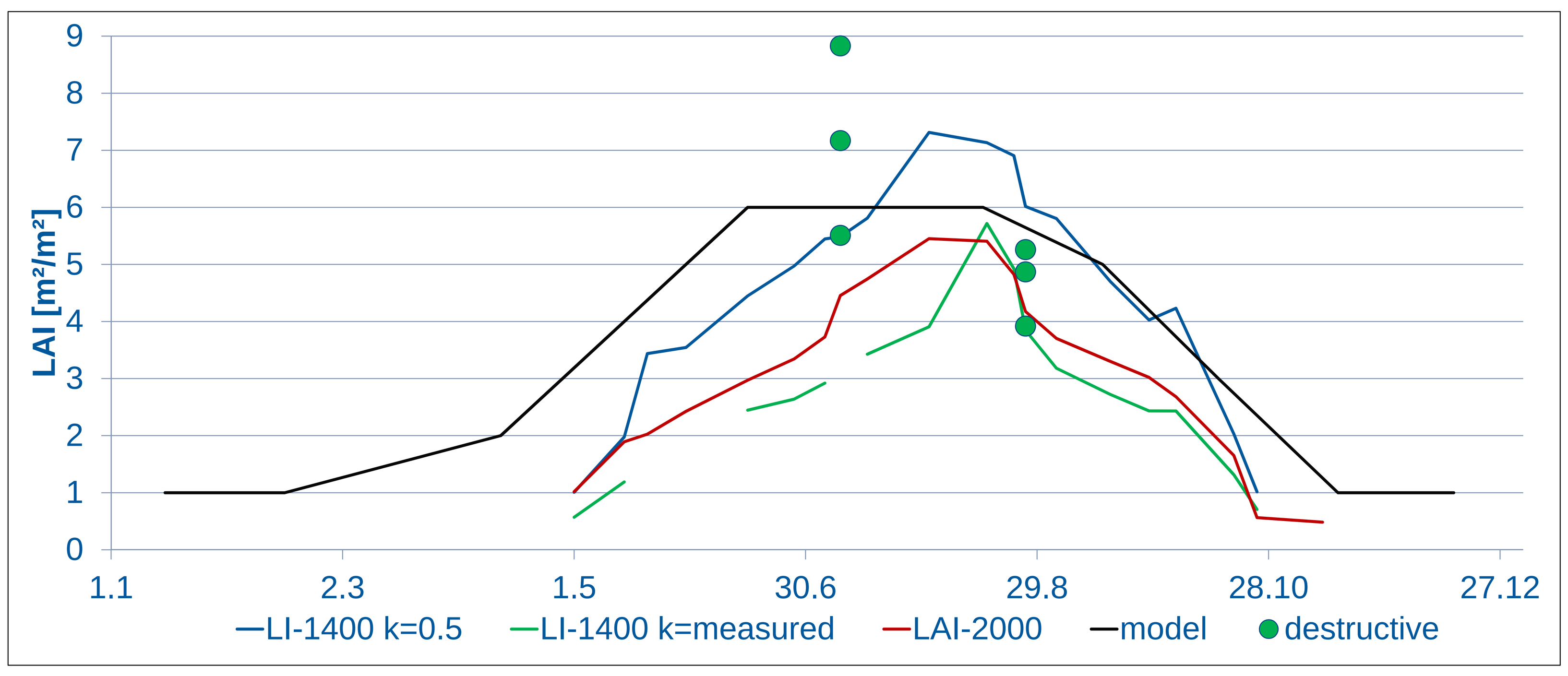

Fig. 2: seasonal development of measured leaf area by 3 optical methods (considering the effect of extinction coefficient k) and one destructive sampling in 2013.

Figure 2 confirms the maximum **LEAF AREA INDEX** by measurements, the foliation is delayed in 2013 due to late frost periods and is not considered in the model. The spread of LAI measurements is presented in Fig. 2 as well.

The parameterization of **DYNAMIC PHENOLOGY** (method 4 in WaSim) is derived from observation as well. The parameters **T0**, **T1** are the temperature threshold for cold days and heat sums respectively, **a** and **b** are regression parameters. These species specific parameters could be derived for a poplar SRC as:

$$T0 = 9°C; T1 = 4°C; a = 1775; b = -350$$

ROOT DEPTH is set to 1.2 m, from observations at plot site.

ROOT DISTRIBUTION is set to 0 (e.g. linear distribution) and used as calibration parameter.

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Model results on measurement level

Using the described parameterization for the land use poplar SRC together with the derived meteorological and soil-physical properties, WaSim-ETH was able to model the soil water properties. Figure 3 shows a comparison of 3 measured time series of soil water content in 60 cm depth and the model results.

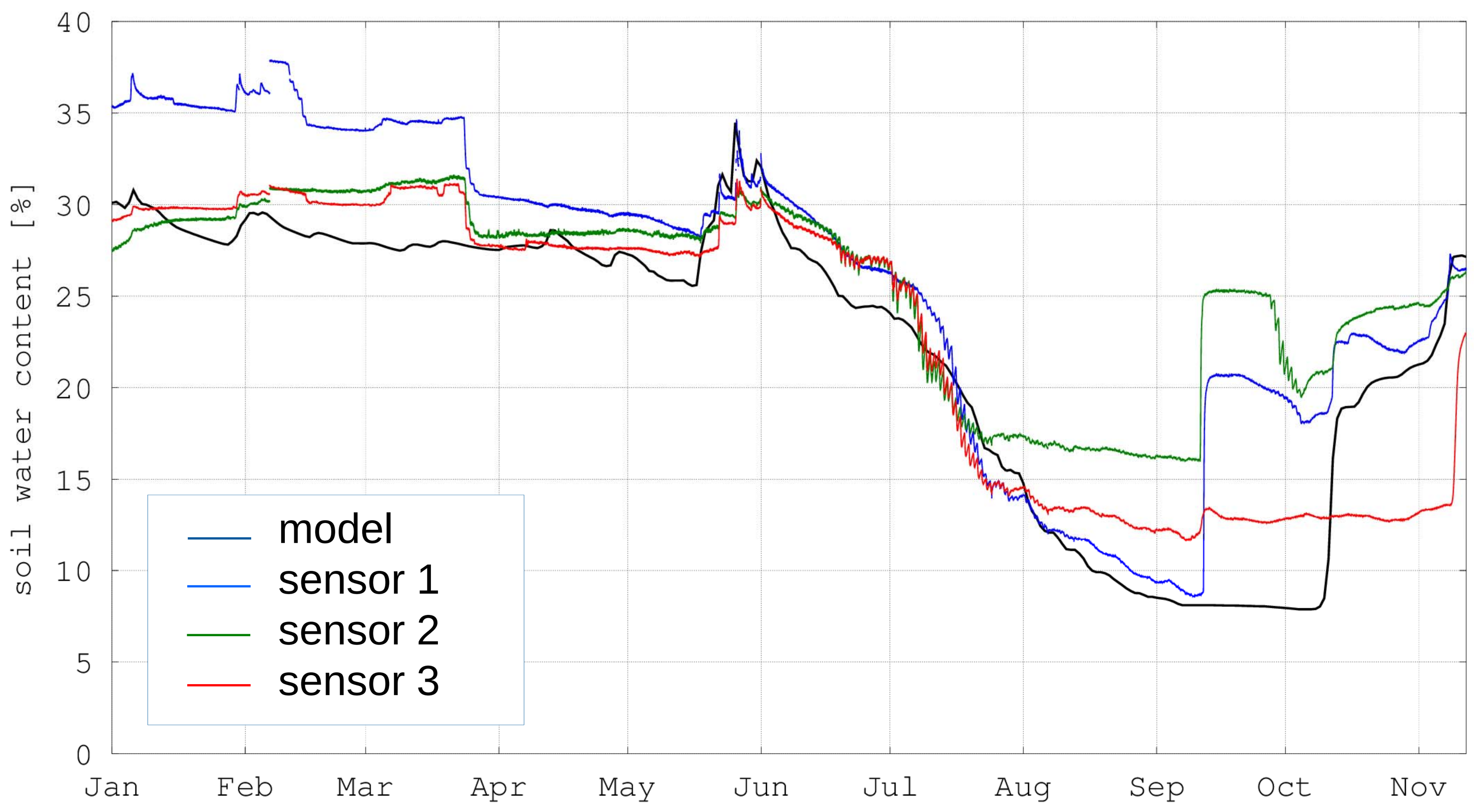

Fig. 3: comparison of modelled soil water content in 60cm depth to measurements (3 repetitions) at the poplar SRC site Reiffenhausen in 2013.

Figure 3 shows a good agreement of measured and modeled soil water contents. Especially the summer time period with drying out soil conditions is represented well by the model. Differences to measured soil water contents occur in the rewetting phase, were the model shows a rewetting signal, that is in the spread of measured signals. The measurement of the rewetting phase is difficult anyway due to preferential flow in shrinkage fissures and at the measurement device.

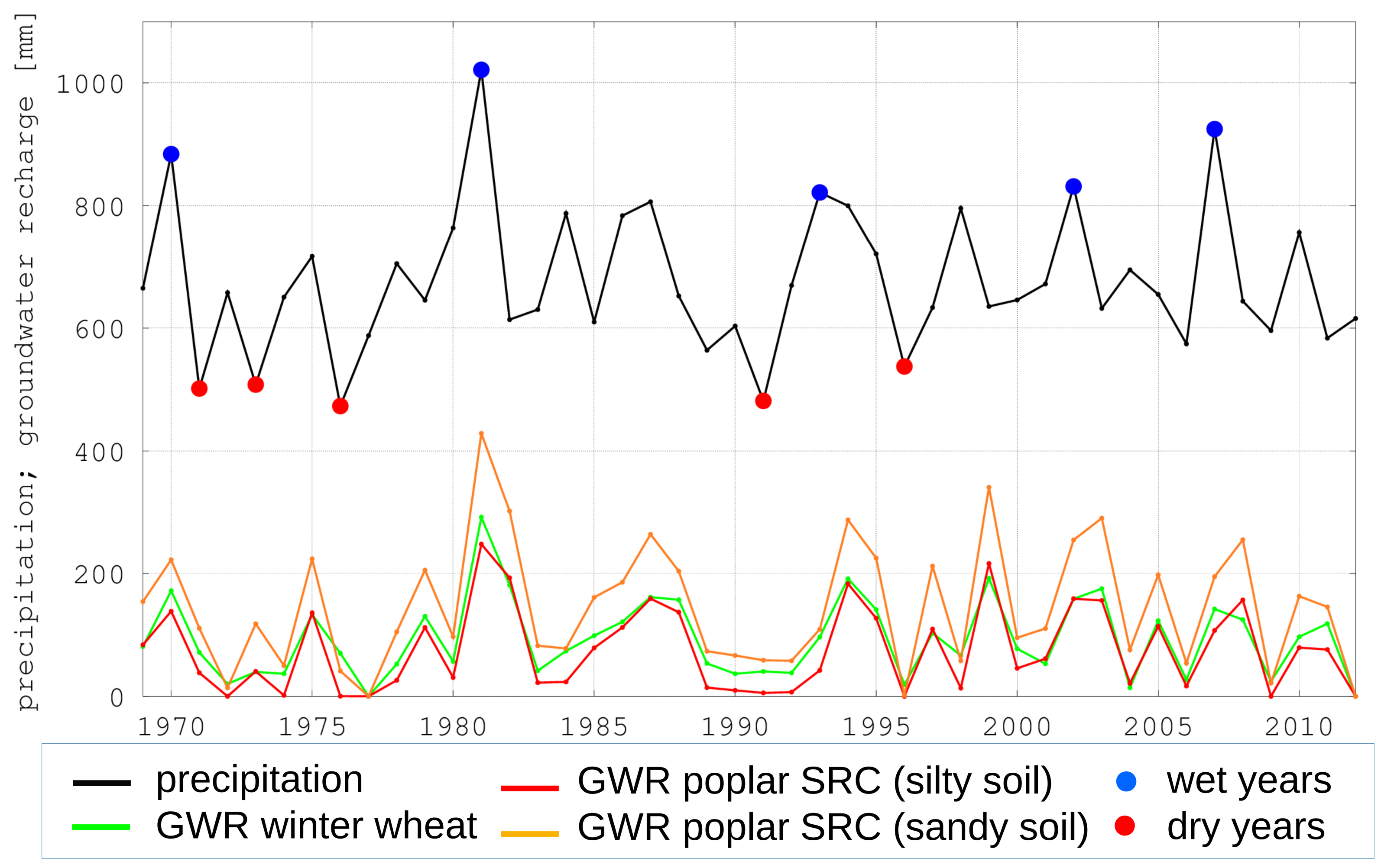

Fig. 4: annual values of precipitation and Ground Water Recharge modeled at the measurement plot for land use winter wheat and poplar SRC for silty and sandy soil respectively. Blue and red dots indicating the 5 wettest and dryest years in the period 1969 to 2012.

Figure 4 shows model results of ground water recharge (GWR), that is defined here as the vertical flux at 2 m depth, for different land use types and soil types. GWR derived from modelling using the mainly measured vegetation properties are very low or even absent in periods of dry years for SRC compared to winter wheat. Due to the good agreement of model results to measured soil water potentials and contents these low or even missing GWR rates are reliable. The difference in GWR of SRC for different soil types, resulting in different soil water capacities show the importance of a proper parameterization of soil properties in hydrological modelling, especially for highly water-consuming vegetation types. Table 1 summarizes the annual mean values of GWR.

Tab. 1: mean annual values of precipitation and ground water recharge according to Fig.4.

	mean (period 1969-2012)	mean (5 dryest years)	mean (5 wettest years)
precipitation	676 mm	500 mm	896 mm
GWR winter wheat	93 mm	48 mm	172 mm
GWR poplar SRC (silty soil)	75 mm	16 mm	138 mm
GWR poplar SRC (sandy soil)	145 mm	66 mm	242 mm

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