



Supplement of

Coupled modelling of hydrological processes and grassland production in two contrasting climates

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Supplementary information

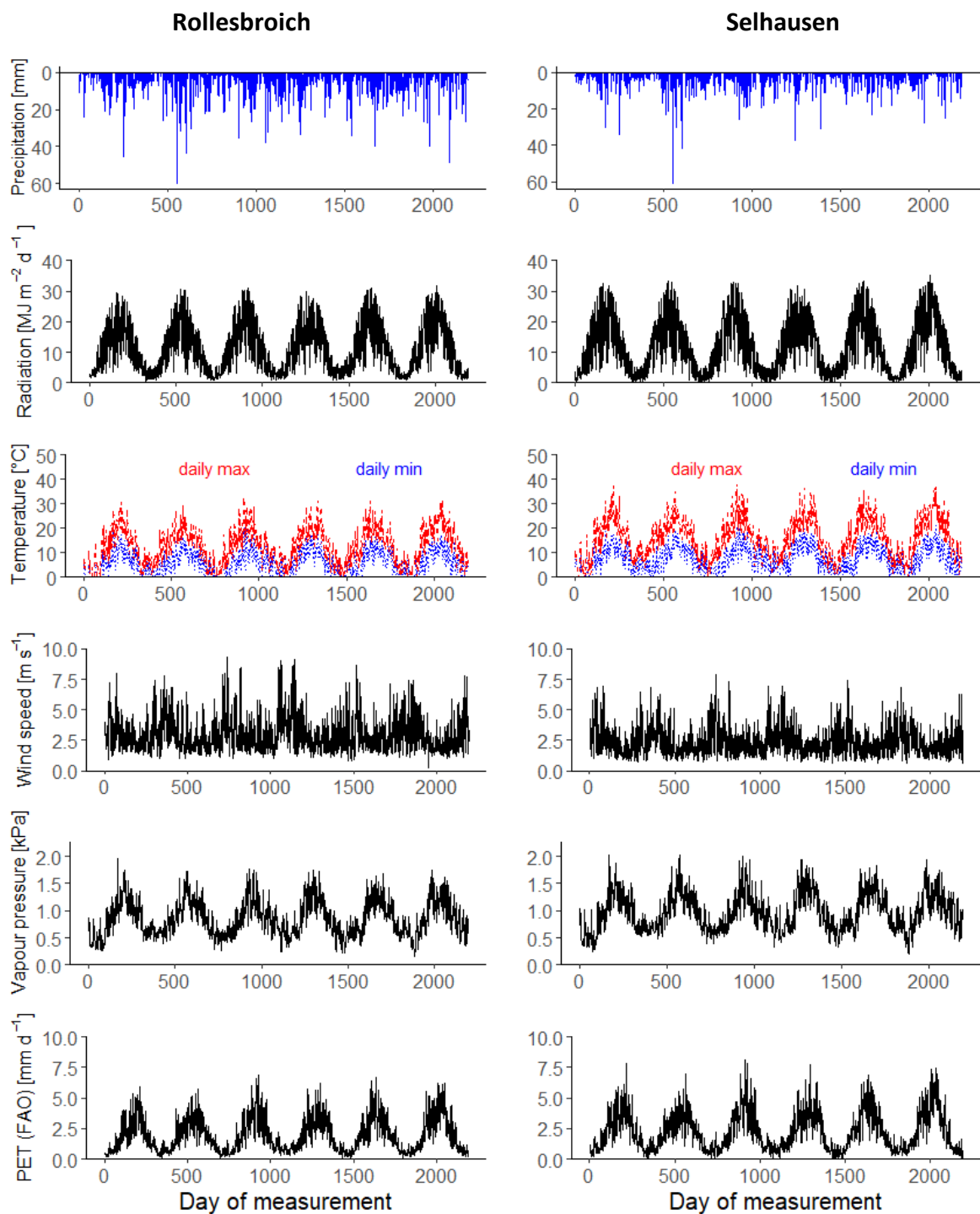


Figure S1: Meteorological variables recorded at Rollesbroich and Selhausen aggregated to daily values (2013-2018; day 1 = 1st January 2013) and calculated potential evapotranspiration using the FAO version of the Penman-Monteith equation (Allen et al., 1998).

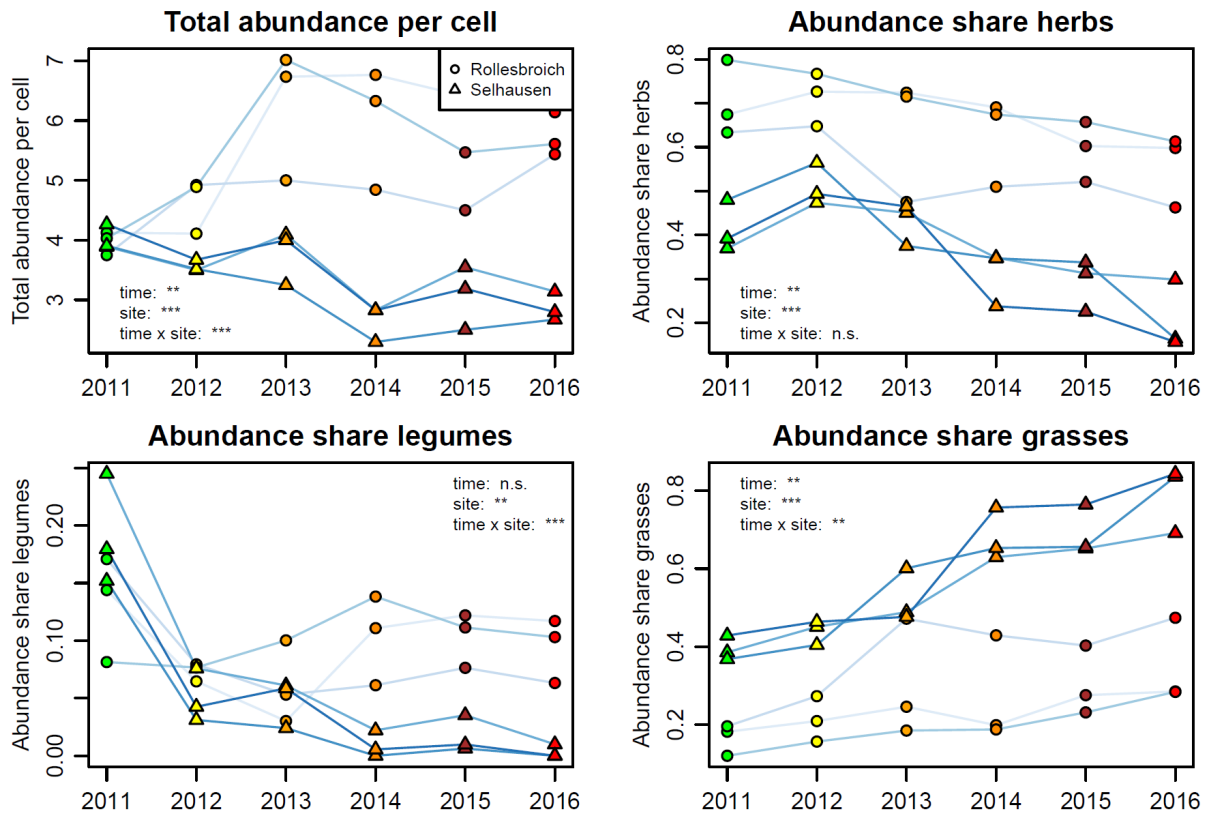


Figure S2. Total species abundance per cell and relative abundances of functional plant types. The results of a linear model analysis are depicted in each figure to indicate the significance of the effects of time, site (Rollesbroich vs. Selhausen) and the interaction of time and site: n.s. $p > 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

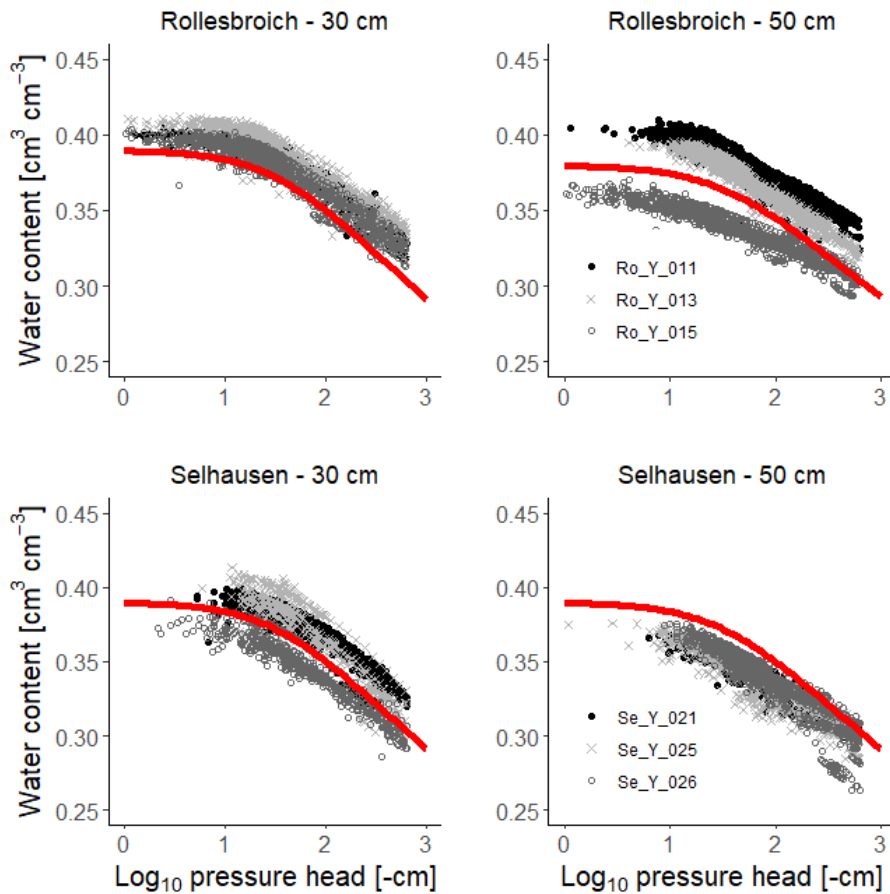


Figure S3. Paired measurements of soil water content and pressure head at 30 and 50 cm depth at Selhausen and Rollesbroich in the period 2013-2018. The red lines show the common water retention curves used in the modelling for the two sites at each depth (the equivalent parameter values are shown in table 3 in the paper). Table S1 below shows parameter values derived from least-squares fits to the individual data series for each lysimeter/depth combination.

Table S1. van Genuchten parameters derived from fits to individual data sets

Depths (cm)	Lysimeter	θ_s ($\text{m}^3 \text{m}^{-3}$)	α (cm^{-1})	n (-)
30	Se_Y_021	0.391	0.005	1.17
	Se_Y_025	0.391	0.003	1.33
	Se_Y_026	0.379	0.030	1.09
50	Ro_Y_011	0.402	0.020	1.06
	Ro_Y_013	0.409	0.030	1.07
	Ro_Y_015	0.400	0.030	1.05

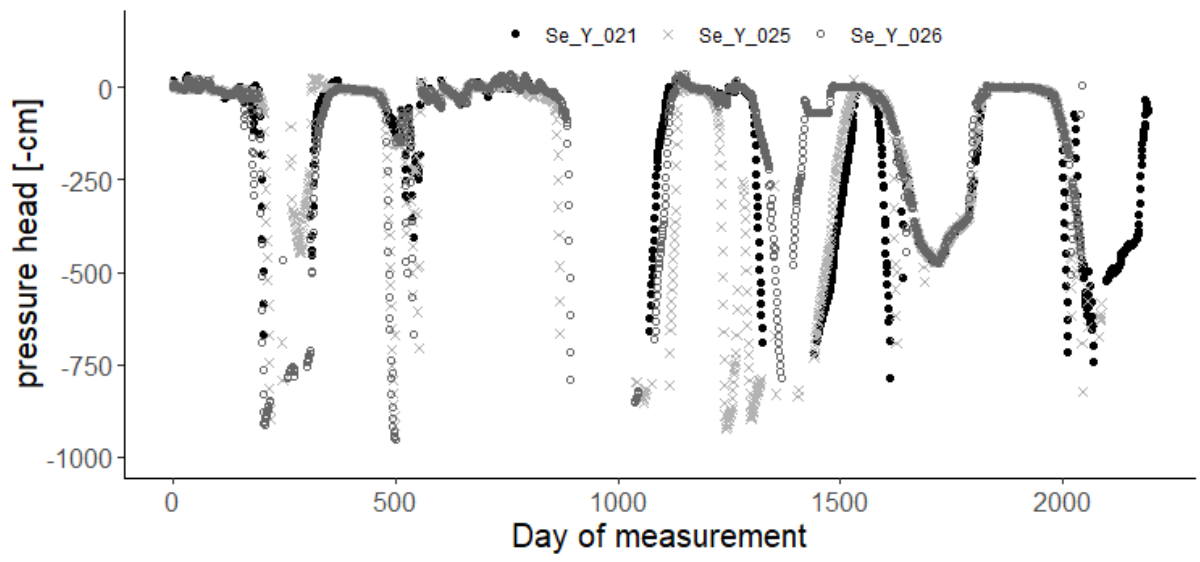
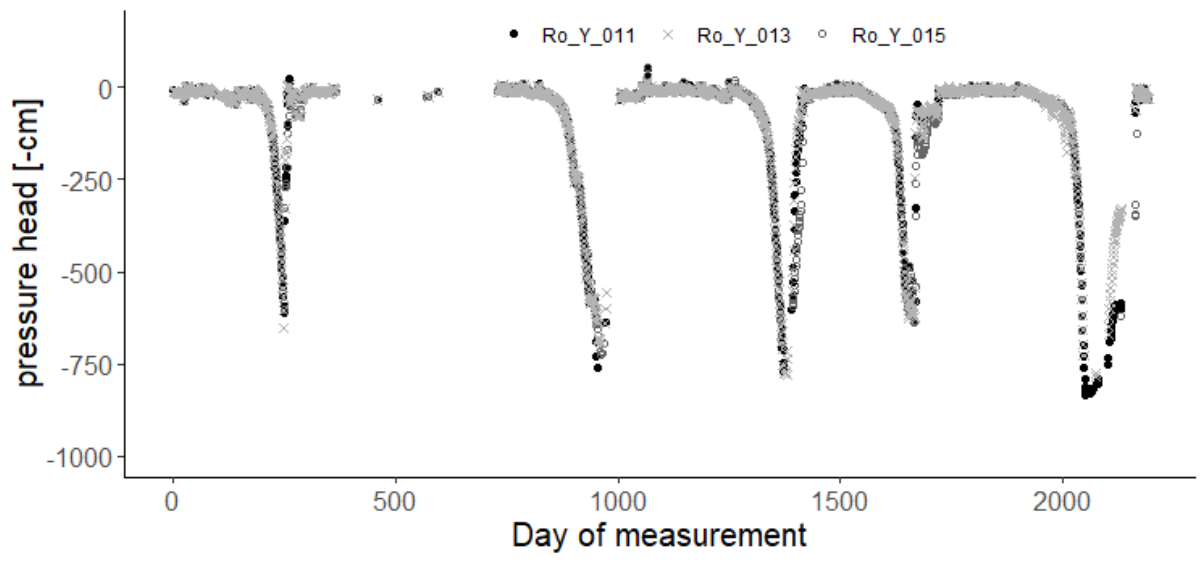


Figure S4. Pressure heads measured in the surrounding soil at 1.4 m depth at the two sites in the period 2013-2018 (day 1 is 1st January 2013).

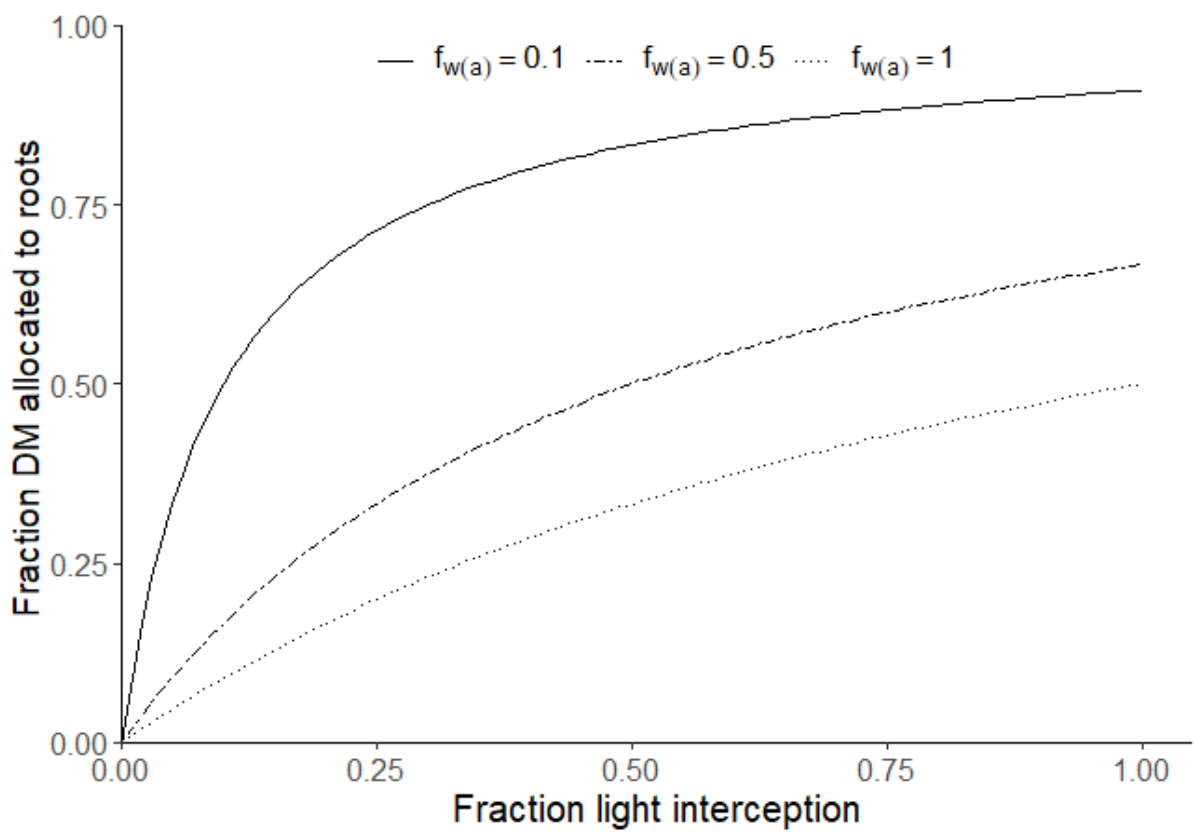


Figure S5. Illustration of equation 30, showing how DM allocation in the model varies as a function of light interception (f_{int} in equation 12) and soil water stress ($f_{w(a)}$ in equation 35). In this example, the proportion of DM allocated to roots under optimal conditions, $f_{bg(opt)}$, is set to 0.5, while air temperature is within the optimum range (i.e. $f_{t(a)} = 1$, equation 36).

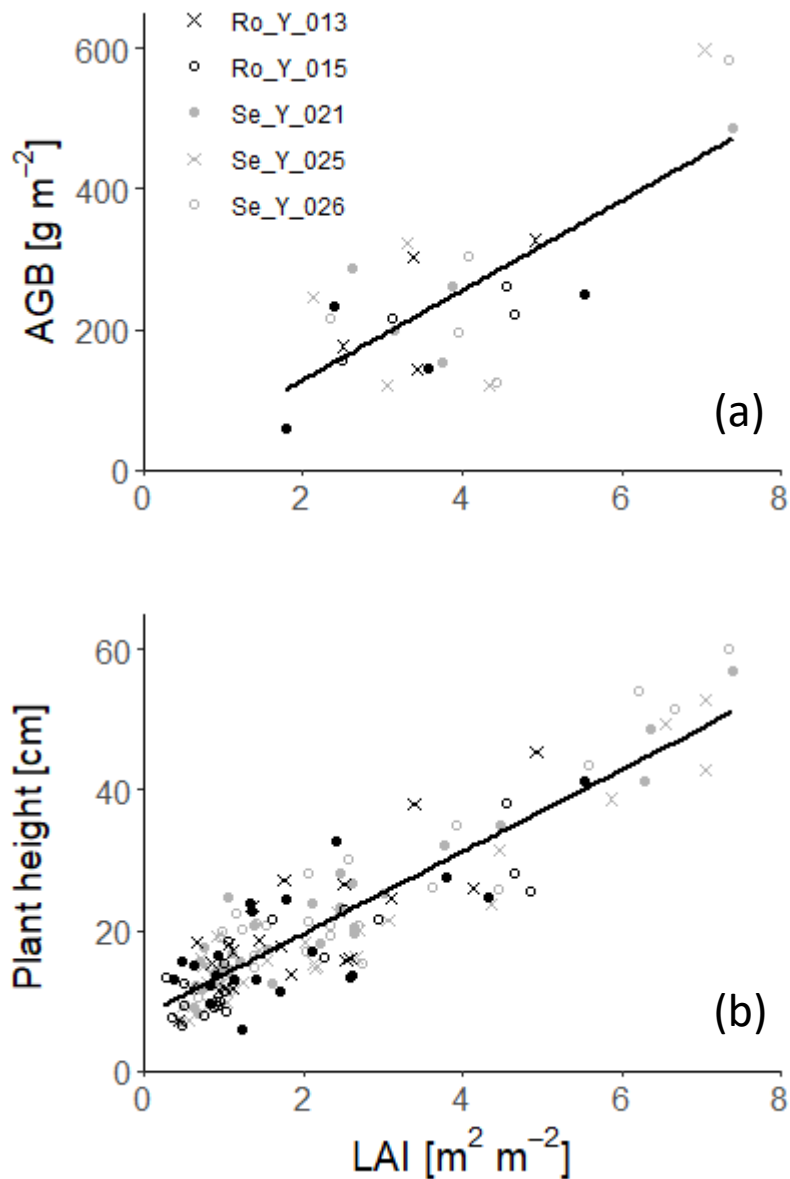


Figure S6. Relationships between leaf area index (LAI) at Rollesbroich and Selhausen (data from 2013-2018) and (a) above-ground biomass (linear regression forced through origin, $\text{AGB} (\text{g m}^{-2}) = 63.8 \text{ LAI}$; $p < 0.0001$, $\text{RMSE} = 86.7 \text{ g m}^{-2}$) and (b) plant height. A bi-linear function was used in the model to describe this relationship; the linear regression equation shown on the figure was used for $\text{LAI} > 0.2$; $\text{Height (cm)} = 7.84 + 5.85 \text{ LAI}$; $R^2 = 0.81$, $p < 0.0001$, $\text{RMSE} = 4.8 \text{ cm}$, while for $\text{LAI} < 0.2$, $\text{Height (cm)} = 45 \text{ LAI}$.

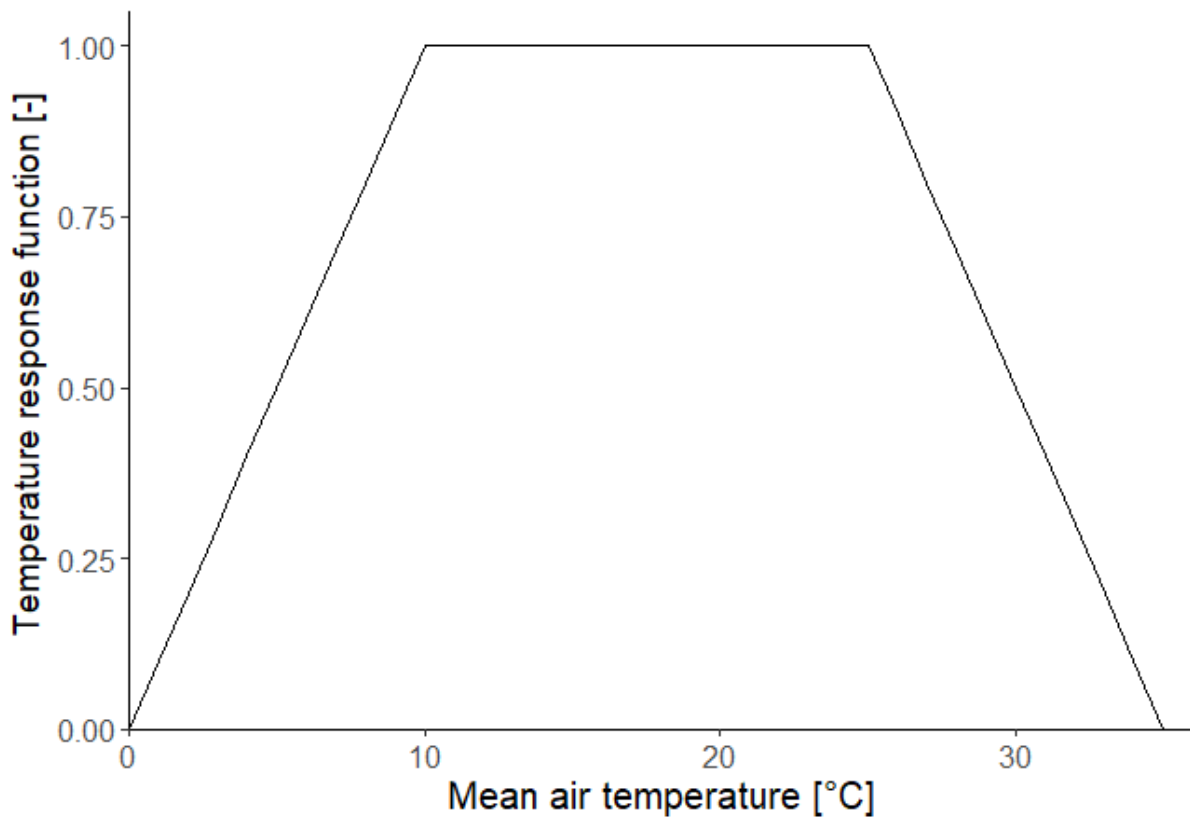


Figure S7. Illustration of the temperature response function in the model (equation 36). In this example, $T_b = 0^\circ\text{C}$, $T_{o(\text{low})} = 10^\circ\text{C}$, $T_{o(\text{high})} = 25^\circ\text{C}$ and $T_c = 35^\circ\text{C}$.

Table S2. Sensitivity analysis: sampled parameter ranges and Spearman rank partial correlation coefficients (**p<0.01; *p<0.05)

Parameter	Sampled range	Selhausen		Rollesbroich	
		Evapotranspiration	Harvest	Evapotranspiration	Harvest
Soil parameters					
van Genuchten's α (cm ⁻¹)	0.02 to 0.03	-0.39**	0.01	-0.15*	0.17**
Scaling factor for van Genuchten's n (-)	0.95 to 1.05	0.39**	0.37**	0.36**	0.20**
Scaling factor for hydraulic conductivity, K_{10} (-)	0.8 to 1.2	0.41**	0.12	0.10	-0.10
Surface resistance of wet soil, r_s^5 (s m ⁻¹)	5 to 25	-0.34**	0.04	-0.60**	0.03
Above-ground plant parameters					
Maximum radiation use efficiency, RUE_{max} (MJ m ⁻² d ⁻¹)	1.4 to 1.8	0.55**	0.66**	0.57**	0.74**
Radiation extinction coefficient, β (-)	0.4 to 0.8	0.68**	0.72**	0.64**	0.87**
Light saturation constant, R_{50} (MJ m ⁻² d ⁻¹)	0 to 10	-0.48**	0.28**	-0.63**	0.15*
Leaf loss coefficient, k_{ag} (d ⁻¹)	0.005 to 0.05	-0.54**	-0.65**	-0.60**	-0.72**
Maximum stomatal conductance, $k_{sto(max)}$ (cm s ⁻¹)	0.5 to 1.5	0.66**	-0.66**	0.77**	-0.39**
Specific leaf area, S_{leaf} (cm ² g ⁻¹)	130-150	0.32**	0.01	0.29**	0.23**
Base temperature (for leaf loss and allocation), T_b (°C)	3 to 6	-0.07	-0.11	-0.22**	-0.34**
Optimum temperature, $T_{o(low)}$ (°C)	9 to 15	-0.64**	-0.59**	-0.71**	-0.81**
Optimum temperature, $T_{o(high)}$ (°C)	20 to 30	0.04	0.00	-0.09	-0.05
Ceiling temperature, T_c (°C)	30 to 40	0.11	0.06	0.02	0.06
Limiting potential for transpiration cessation, ψ_w (m)	100 to 150	0.02	0.04	0.08	0.01
Limiting potential (DM allocation, leaf loss), $\psi_{o(crit)}$ (cm)	100 to 2000	0.56**	0.80**	0.39**	0.67**
DM allocation to roots under optimal conditions $f_{bg(opt)}$ (-)	0.4 to 0.6	-0.38**	-0.74*	-0.34**	-0.78**
Root parameters					
Root decay constant, k_{bg} (d ⁻¹)	0 to 0.02	-0.37**	-0.17*	-0.37**	-0.02
Root radius, r_o (cm)	0.01 to 0.03	-0.01	0.04	0.05	0.03
Effective root fraction, ε (-)	0 to 0.2	0.62**	0.44**	0.56**	0.19**
Specific root length, S_{root} (m g ⁻¹)	100 to 140	0.15*	0.13	0.12	0.07
Shape factor for root distribution, c (-)	-2 to -1	-0.07	0.09	-0.10	0.02
Maximum root depth, D_r (cm)	40 to 90	0.92**	0.71**	0.79**	0.33**

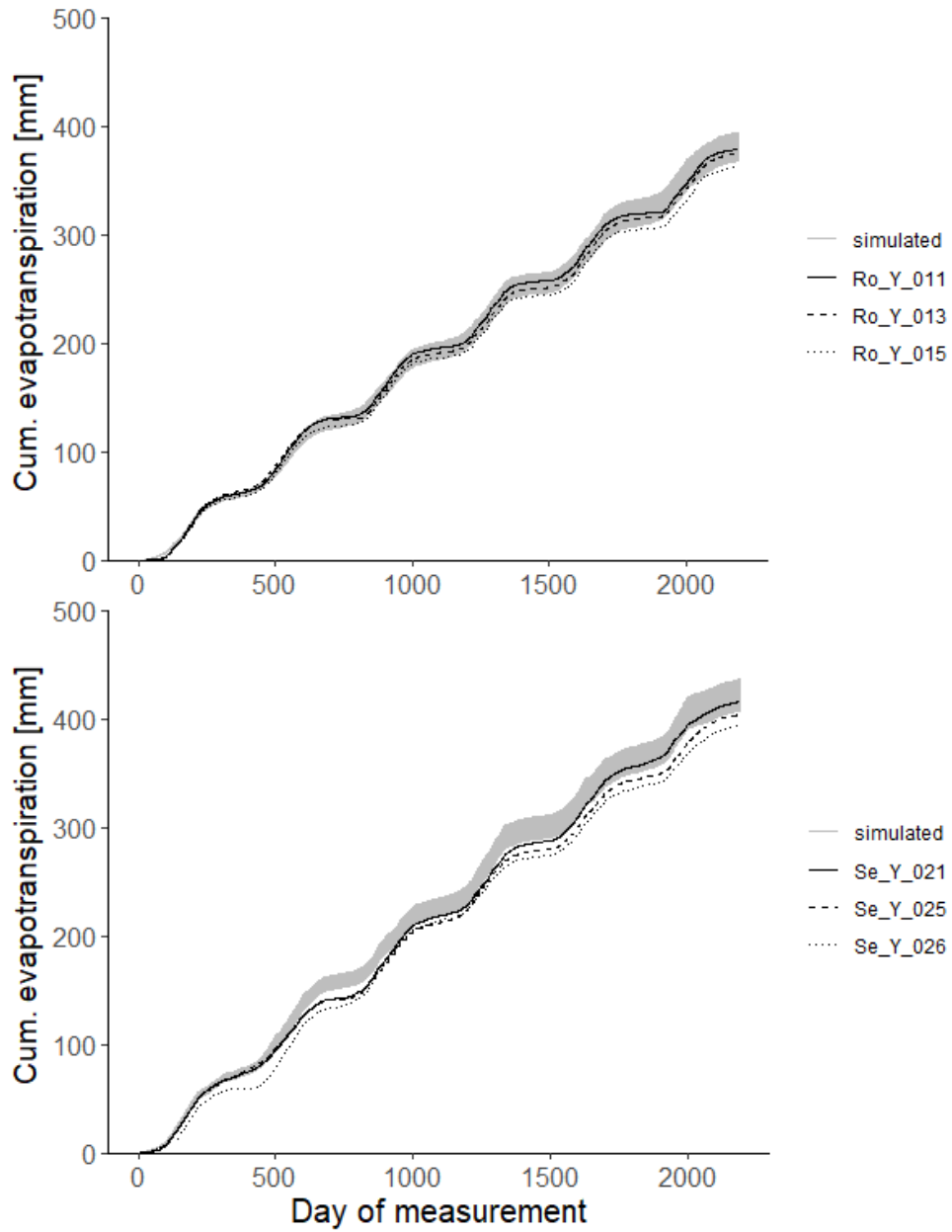


Figure S8. Measured and simulated accumulated evapotranspiration (day 1 = 1st January 2013)

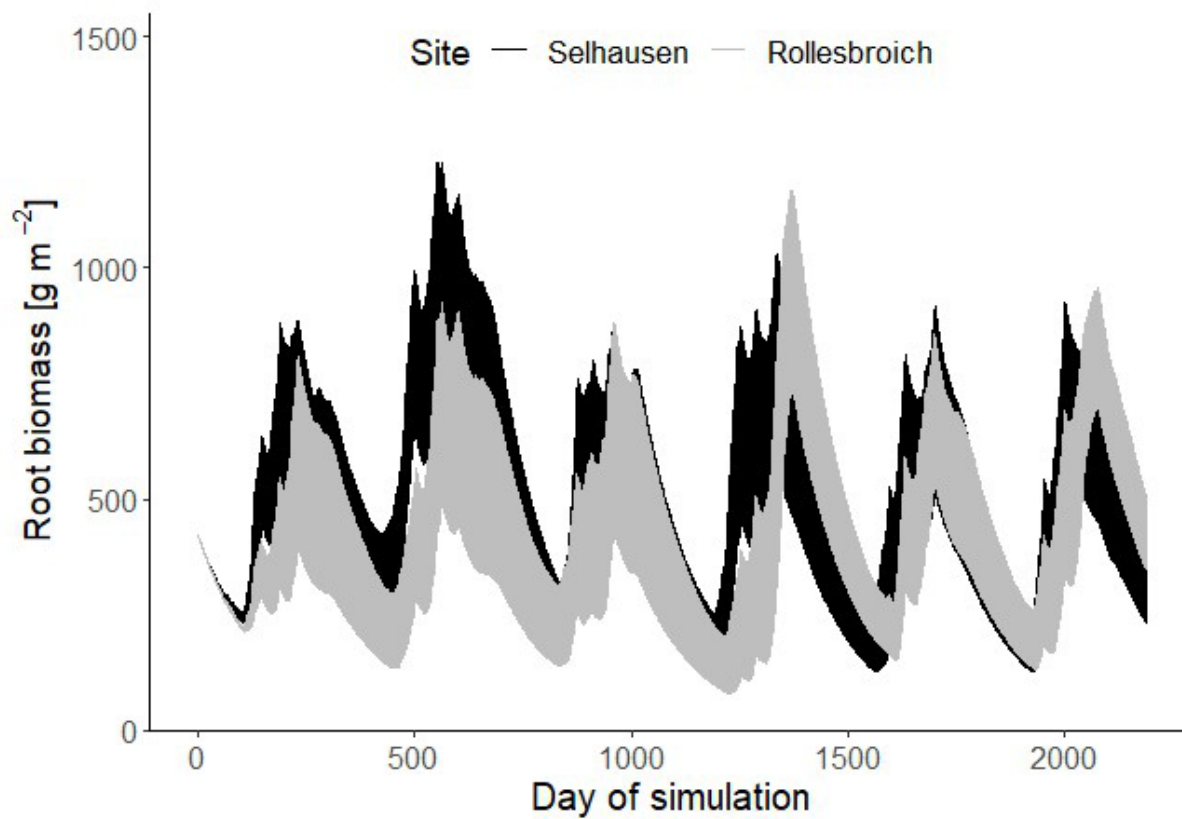


Figure S9. Temporal dynamics of root biomass at Rollesbroich and Selhausen simulated by the model for the 30 acceptable parameterizations. (day 1 = 1st January 2013)