Supplement of

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

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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 | $\theta_s$ (m$^3$ m$^{-3}$) | $\alpha$ (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 ($f_{\text{int}}$ 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, AGB (g m⁻²) = 63.8 LAI; $p<0.0001$, RMSE=86.7 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 LAI > 0.2; Height (cm) = 7.84 + 5.85 LAI; $R^2=0.81$, $p<0.0001$, RMSE=4.8 cm, while for LAI < 0.2, Height (cm) = 45 LAI.
Figure S7. Illustration of the temperature response function in the model (equation 36). In this example, $T_b = 0^\circ C$, $T_{o(low)} = 10^\circ C$, $T_{o(high)} = 25^\circ C$ and $T_c = 35^\circ C$. 
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, Kₛₒ (-)                        | 0.8 to 1.2              | 0.41**    | 0.12          | 0.10       | -0.10      |
| Surface resistance of wet soil, rₛ (s m⁻¹)                               | 5 to 25                 | -0.34**   | 0.04          | -0.60**    | 0.03       |
| **Above-ground plant parameters**                                         |                        |           |               |            |
| Maximum radiation use efficiency, $RUE_{\text{max}}$ (MJ m² 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, $Rₛₒ$ (MJ m² d⁻¹)                             | 0 to 10                 | -0.48**   | 0.28**        | -0.63**    | 0.15*      |
| Leaf loss coefficient, $k_{\text{ag}}$ (d⁻¹)                              | 0.005 to 0.05           | -0.54**   | -0.65**       | -0.60**    | -0.72**    |
| Maximum stomatal conductance, $K_{\text{stom}}$ (cm s⁻¹)                 | 0.5 to 1.5              | 0.66**    | -0.66**       | 0.77**     | -0.39**    |
| Specific leaf area, $S_{\text{leaf}}$ (cm² g⁻¹)                          | 130-150                 | 0.32**    | 0.01          | 0.29**     | 0.23**     |
| Base temperature (for leaf loss and allocation), $Tₛ$ (°C)               | 3 to 6                  | -0.07     | -0.11         | -0.22**    | -0.34**    |
| Optimum temperature, $T_{\text{flow}}$ (°C)                              | 9 to 15                 | -0.64**   | -0.59**       | -0.71**    | -0.81**    |
| Optimum temperature, $T_{\text{opt}}$ (°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), $ψ_{\text{crit}}$ (cm)   | 100 to 2000             | 0.56**    | 0.80**        | 0.39**     | 0.67**     |
| DM allocation to roots under optimal conditions $f_{\text{ag}}$ (d⁻¹)  | 0.4 to 0.6              | -0.38**   | -0.74*        | -0.34**    | -0.78**    |
| **Root parameters**                                                       |                        |           |               |            |
| Root decay constant, $k_{\text{bg}}$ (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, $S_{\text{root}}$ (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)