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Supplement of

RoGeR v3.0.5 – a process-based hydrological toolbox model in Python

Robin Schwemmle et al.

Correspondence to: Robin Schwemmle (robin.schwemmle@hydrology.uni-freiburg.de)

The supplement contains:

- Test cases for continuous development (Sect. S1)
- Energy usage of a notebook (Sect. S2)
- Spatial distribution of model parameters, soil water content and median travel time of percolation (Sect. S3)

S1 Test cases for continuous development

The test cases are simulated with vertical processes only (i.e. no lateral flow and no lateral transfer between cells). The input data covers an entire hydrologic year (from 1st November 2010 to 31st October 2011). We selected an entire hydrologic year to cover different meteorological conditions and keep computation time little. Generally, the two test cases could be modified to test other model structures, for example, considering vertical and lateral processes without lateral transfer between cells.

S1.1 Input data for two different climatic conditions

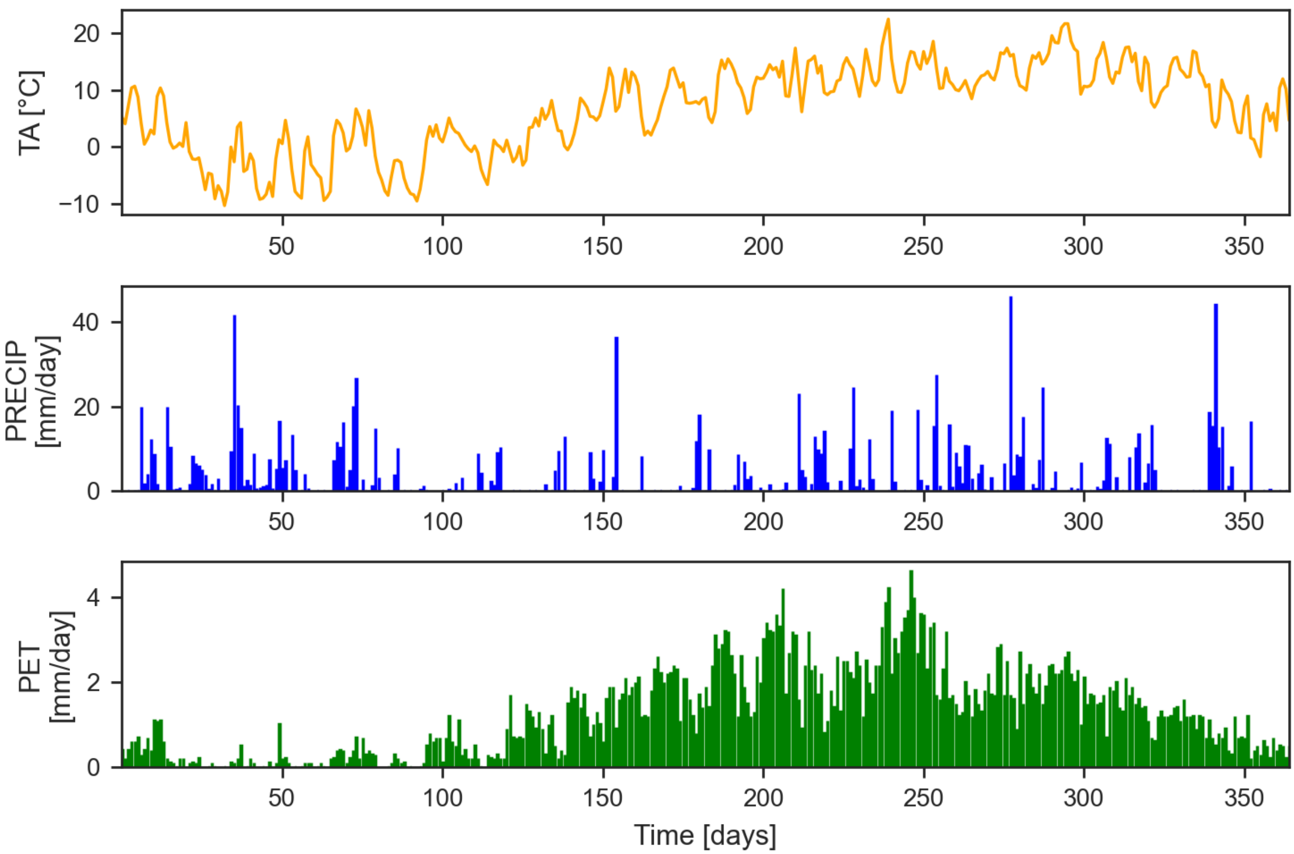


Figure S1 Model input data of a test case for a middle mountain range climate (DWD station Breitnau with station ID 684)

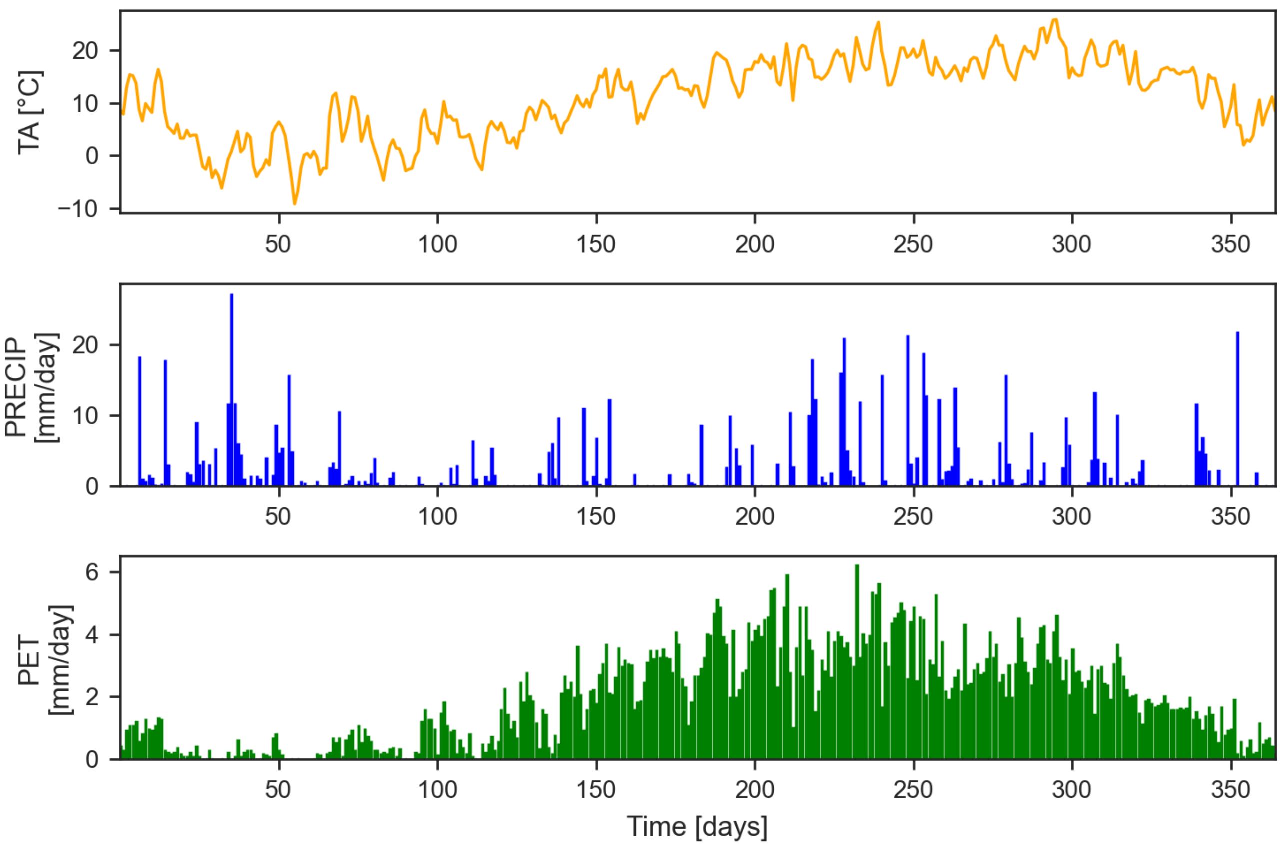


Figure S2 Model input data of a test case for a lowland climate (DWD station Ihringen with station ID 2388)

S1.2 Model parameters of RoGeR for continuous development

Randomly generated parameter sets for test purpose may lead to absurd or unrealistic parameter combination. Therefore, defined parameter sets prevent absurd or unrealistic parameter combination. In order to create physically meaningful parameter combinations, inter-dependencies between different parameters have to be considered. For example, soil properties such as plant available field capacity or air capacity should be in the range of the corresponding soil type. The defined test parameter set is derived from available environmental data of the state of Baden-Württemberg, Germany. Distributions of the defined test parameters are displayed in Fig. S3.

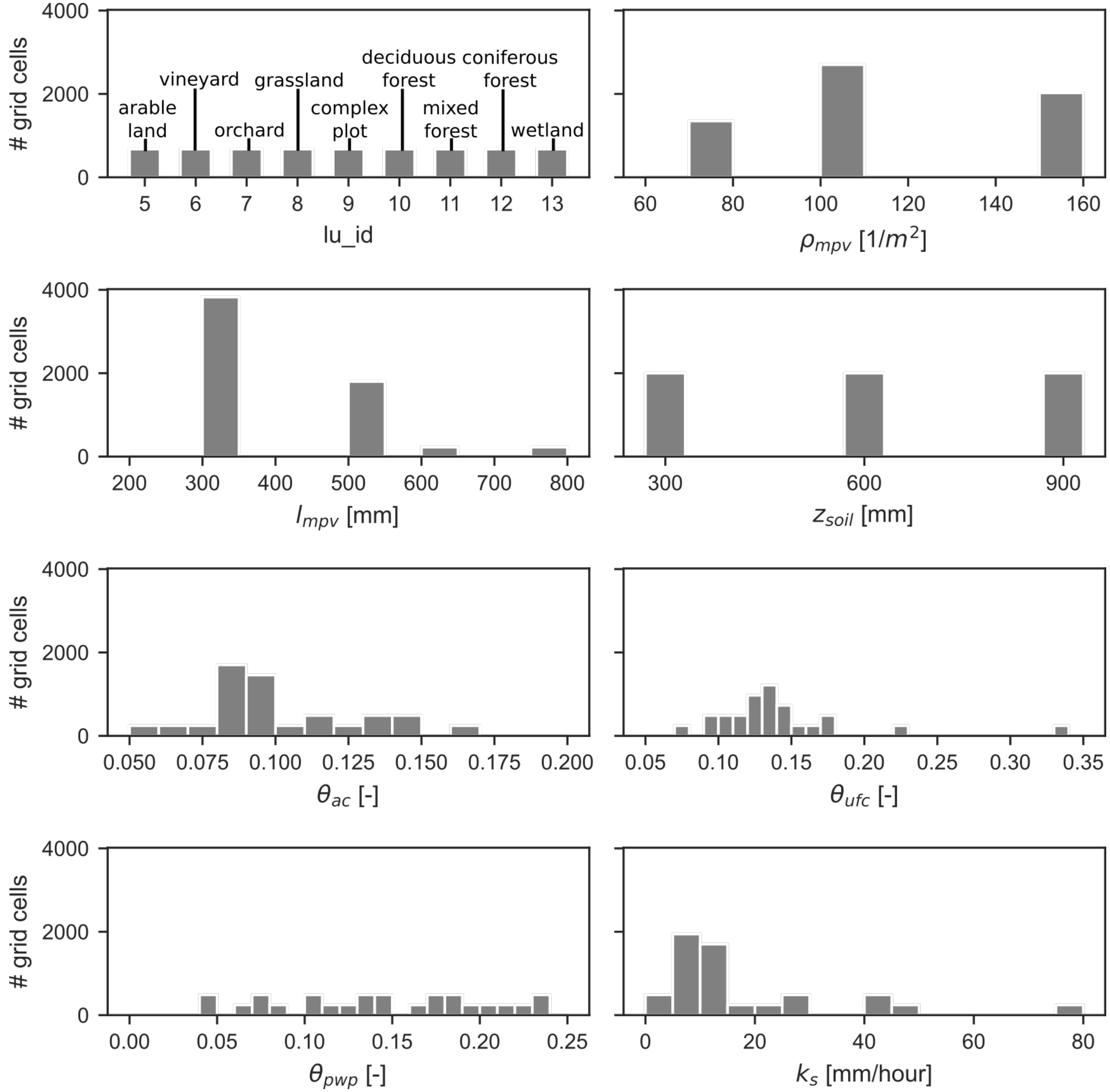


Figure S3 Distribution of model parameters used for test cases of continuous development (lu_id: Land use/Land cover; ρ_{mpv}: Density of vertical macropores; l_{mpv}: Length of vertical macropores; z_{soil}: Soil depth; θ_{ac}: Air capacity of soil; θ_{ufc}: Plant available field capacity of soil; θ_{pwp}: Permanent wilting point of soil; k_s: Saturated hydraulic conductivity of soil; k_f: Hydraulic conductivity of bedrock)

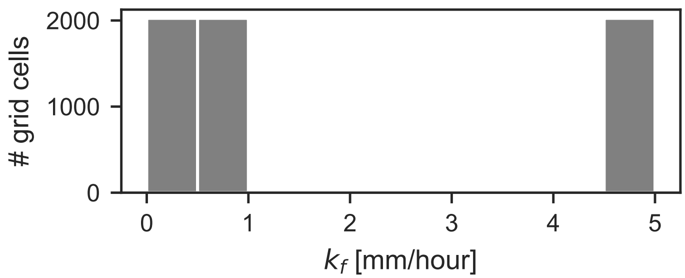


Figure S3 (continued)

S1.3 Time series of simulations for the test cases with middle mountain range climate and lowland climate

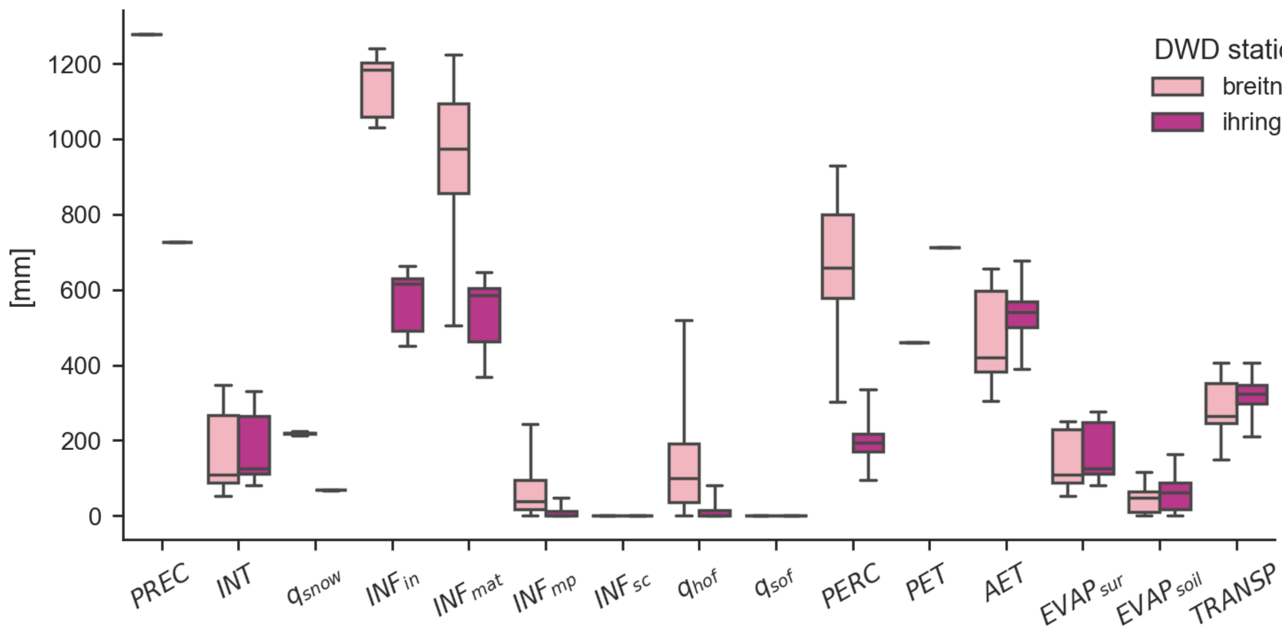


Figure S4 Boxplots for simulated total sums of grid cells. Values are shown for interception (INT), snow melt (q_{snow}), soil matrix infiltration (INF_{mat}), macropore infiltration (INF_{mp}), shrinkage crack infiltration (INF_{sc}), Hortonian surface runoff (q_{HOF}), saturation surface runoff (q_{SOF}), percolation (PERC), actual evapotranspiration (AET), surface evaporation ($EVAP_{sur}$), soil evaporation ($EVAP_{soil}$) and transpiration (TRANSP). Whiskers extend from minimum to maximum.

S1.3.1 Middle mountain range climate

All simulations (Figs. S5-S16) are performed with input data presented in Fig. S1 and model parameters as in Fig. S3.

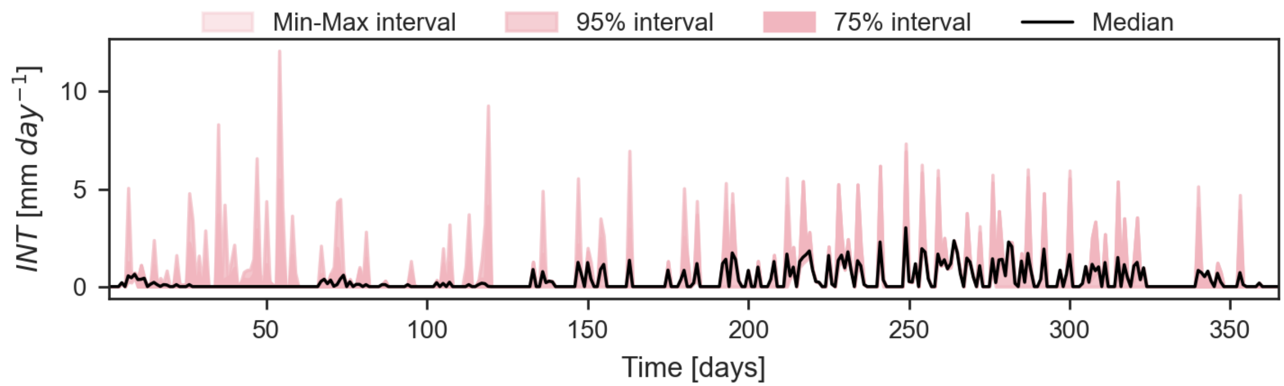


Figure S5 Time series of simulated interception (INT)

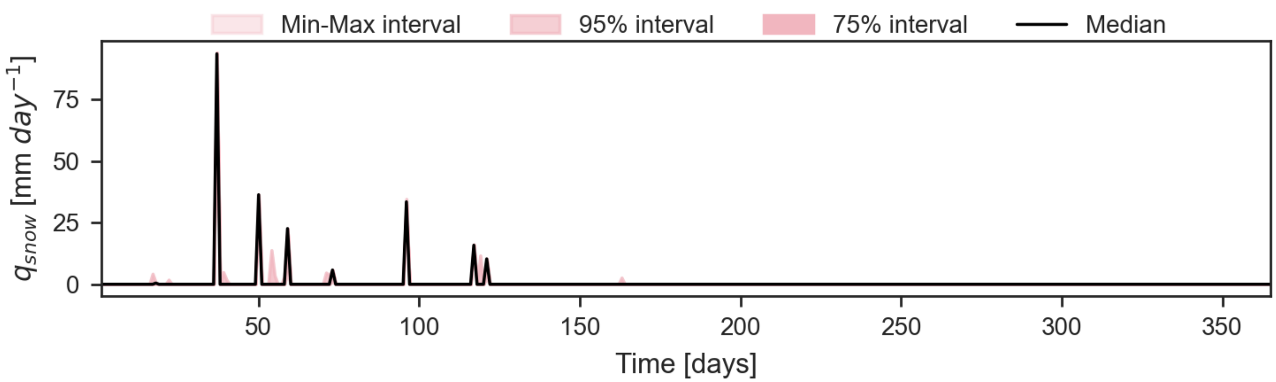


Figure S6 Time series of simulated snow melt runoff (q_{snow})

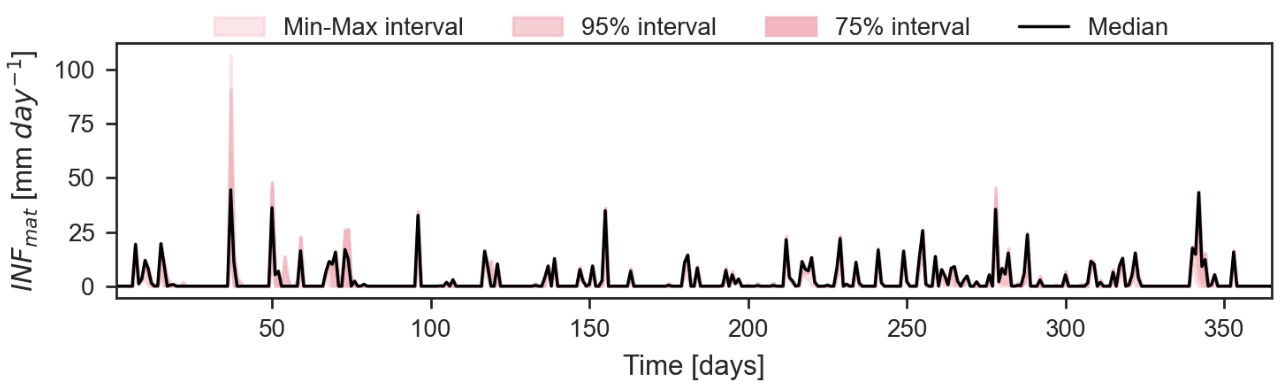


Figure S7 Time series of simulated soil matrix infiltration (INF_{mat})

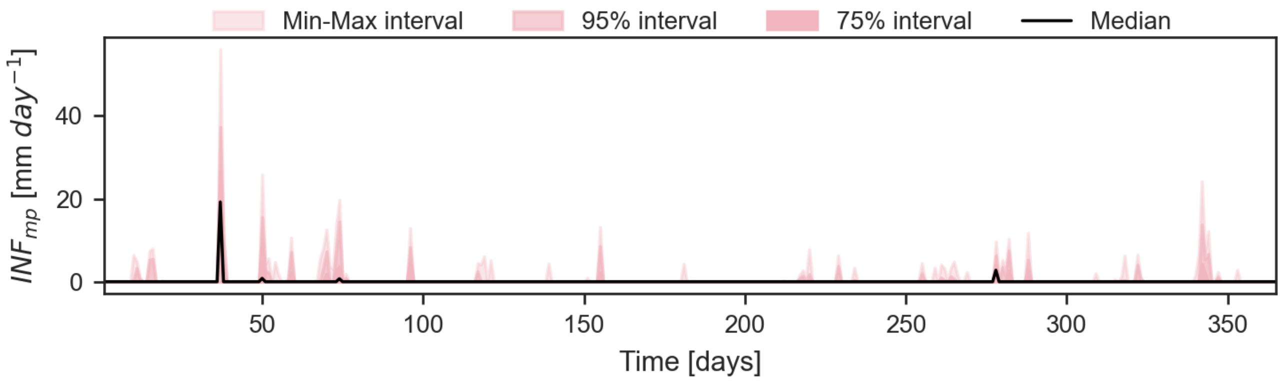


Figure S8 Time series of simulated soil macropore infiltration (INF_{mp})

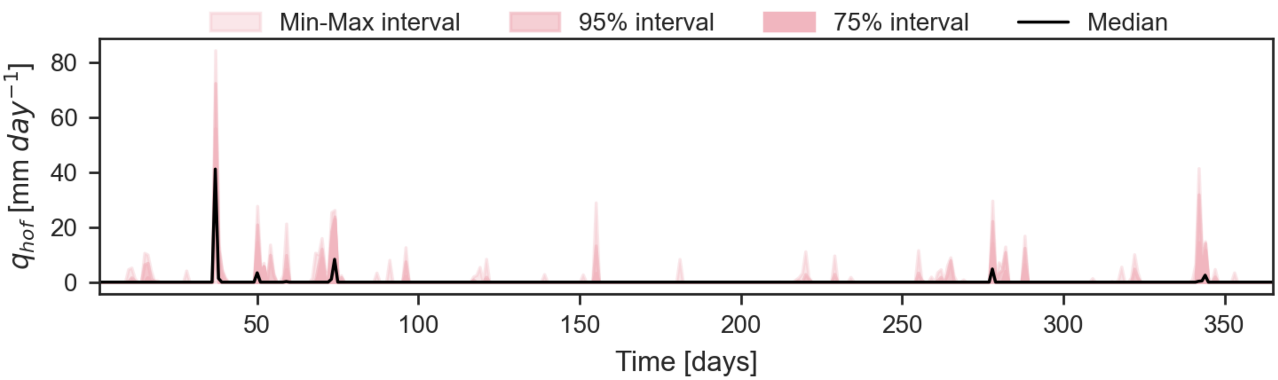


Figure S9 Time series of simulated Hortonian surface runoff (q_{hof})

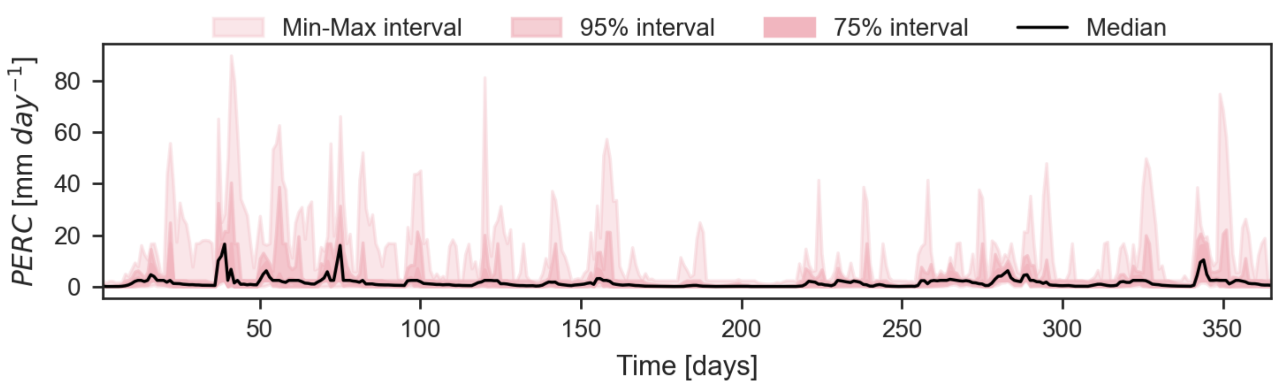


Figure S10 Time series of simulated percolation (PERC)

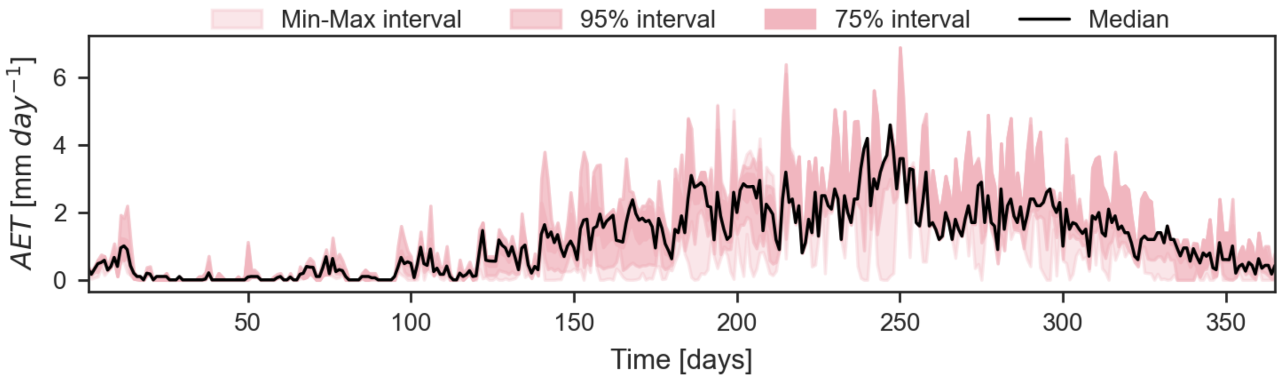


Figure S11 Time series of simulated actual evapotranspiration (AET)

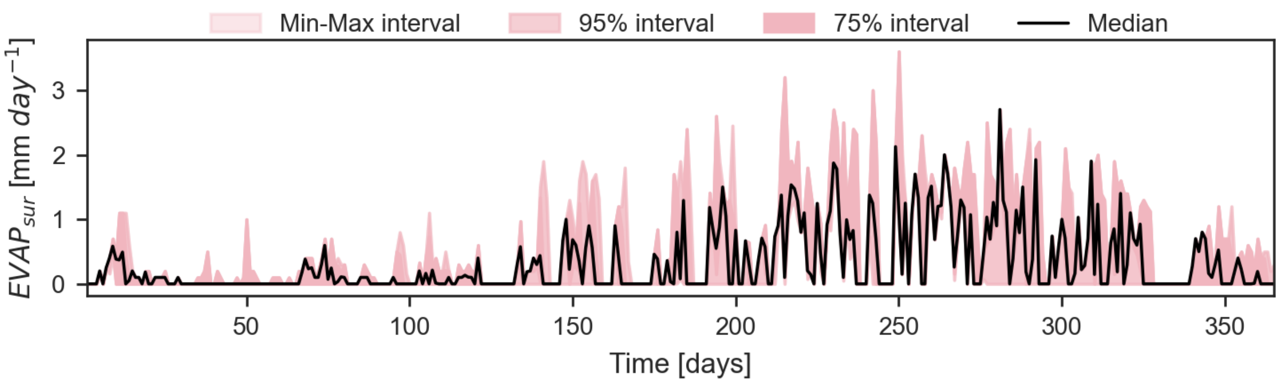


Figure S12 Time series of simulated surface evaporation ($EVAP_{sur}$; i.e. evaporation from interception storage)

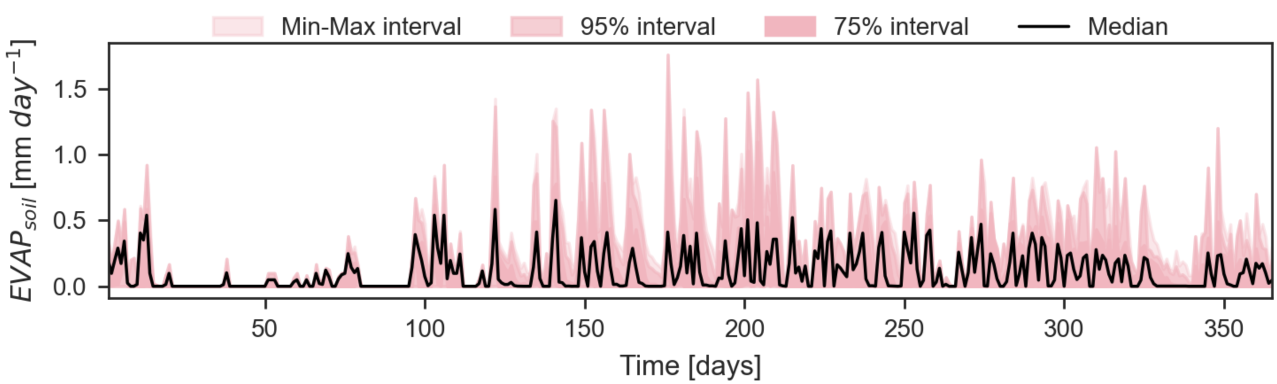


Figure S13 Time series of simulated soil evaporation ($EVAP_{soil}$)

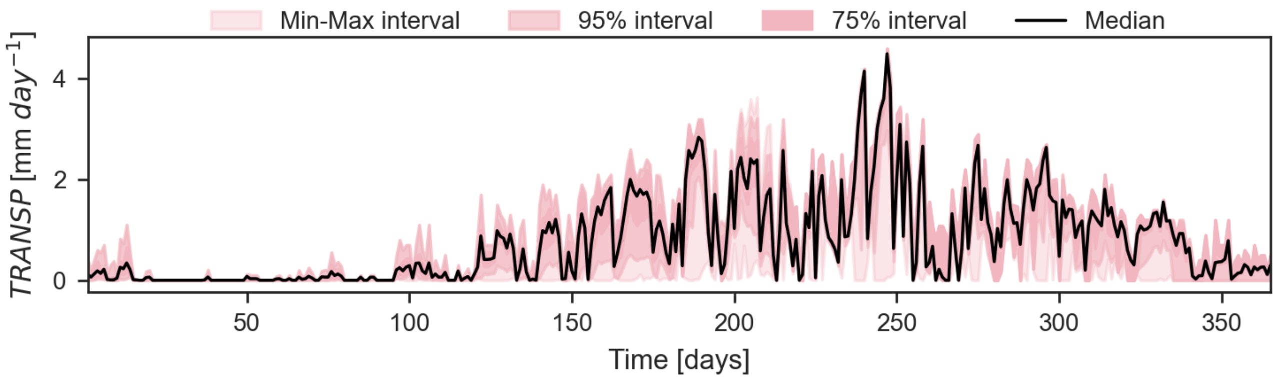


Figure S14 Time series of simulated transpiration (TRANSP; i.e. root water uptake)

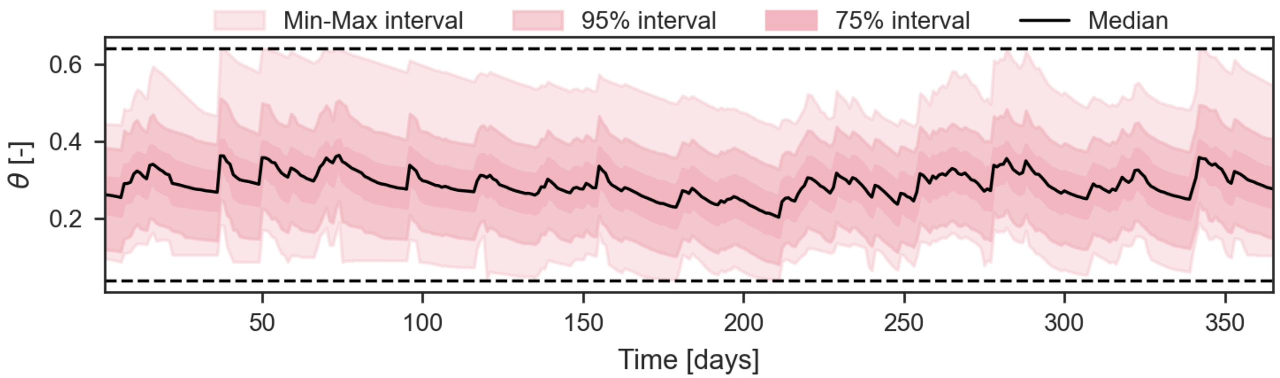


Figure S15 Time series of simulated soil water content (θ)

S1.3.2 Lowland climate

All simulations (Figs. S17-S28) are performed with input data presented in Fig. S2 and model parameters as in Fig. S3.

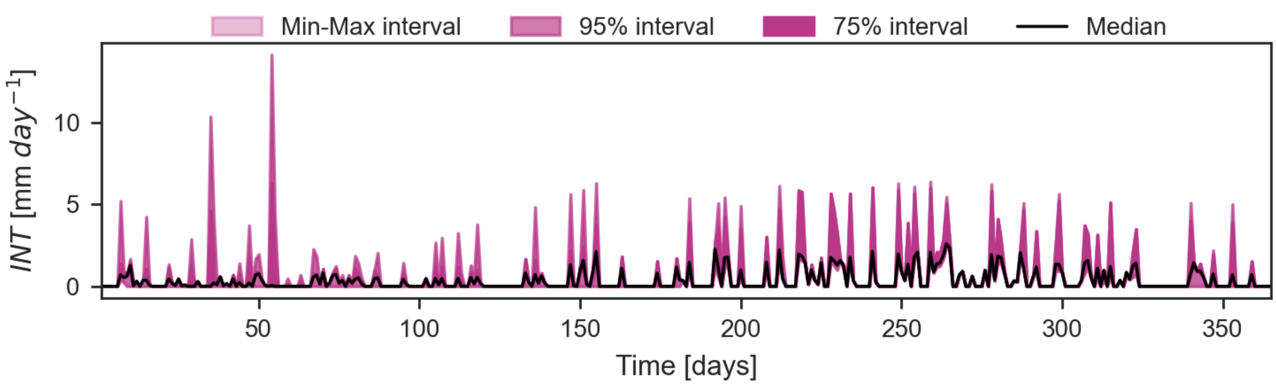


Figure S16 Time series of simulated interception (INT)

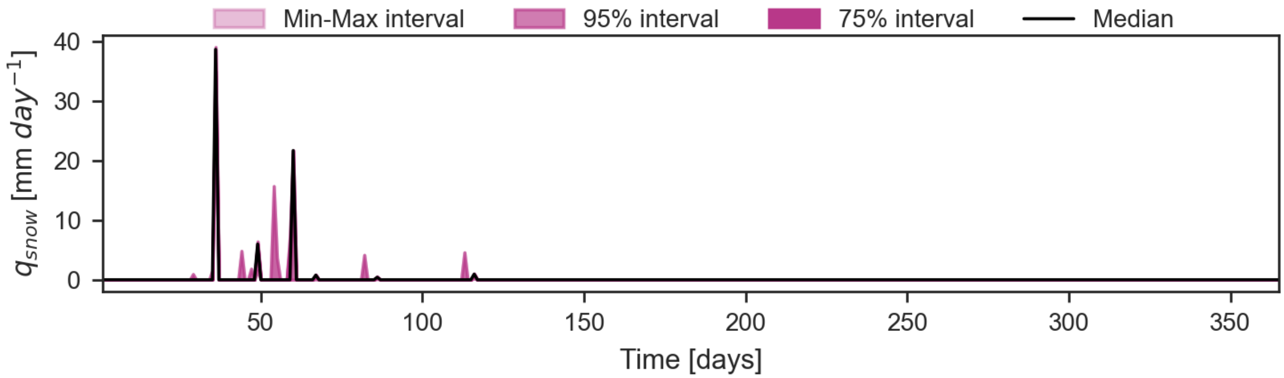


Figure S17 Time series of simulated snow melt runoff (q_{snow})

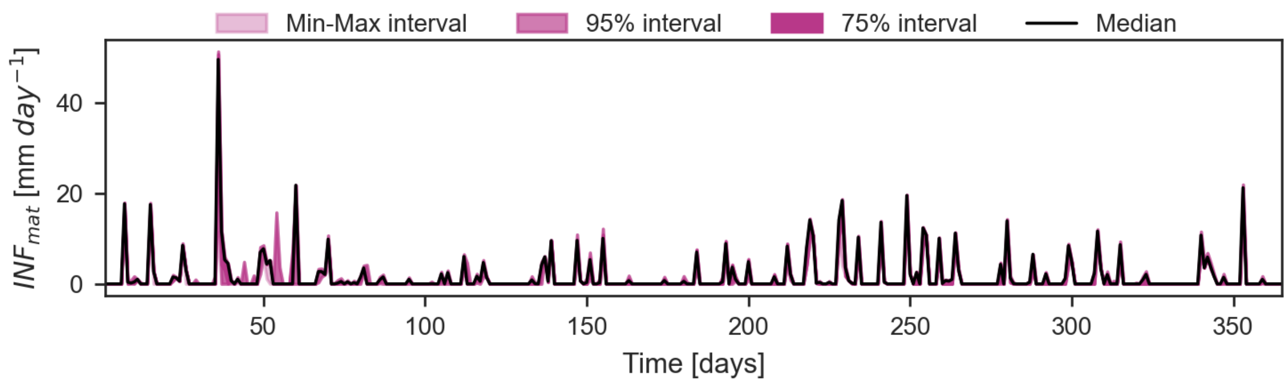


Figure S18 Time series of simulated soil matrix infiltration (INF_{mat})

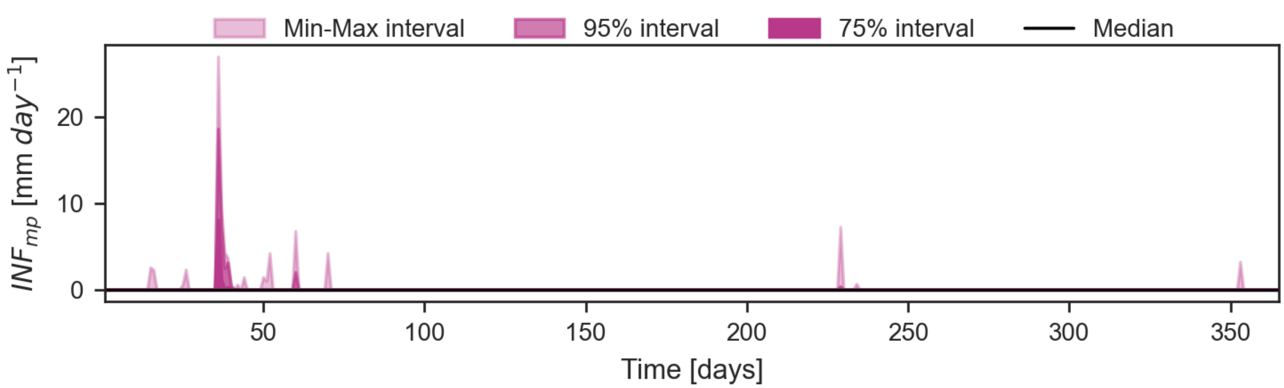


Figure S19 Time series of simulated soil macropore infiltration (INF_{mp})

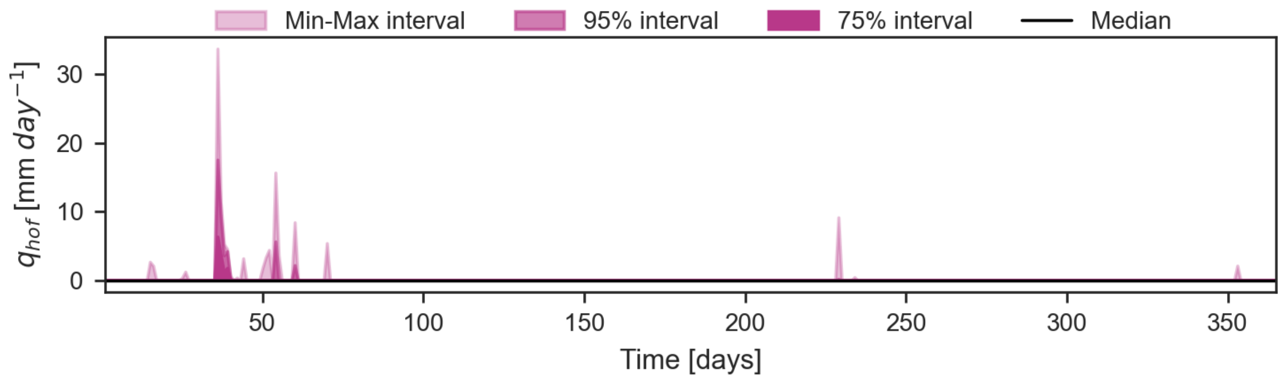


Figure S 20 Time series of simulated Hortonian surface runoff (q_{hof})

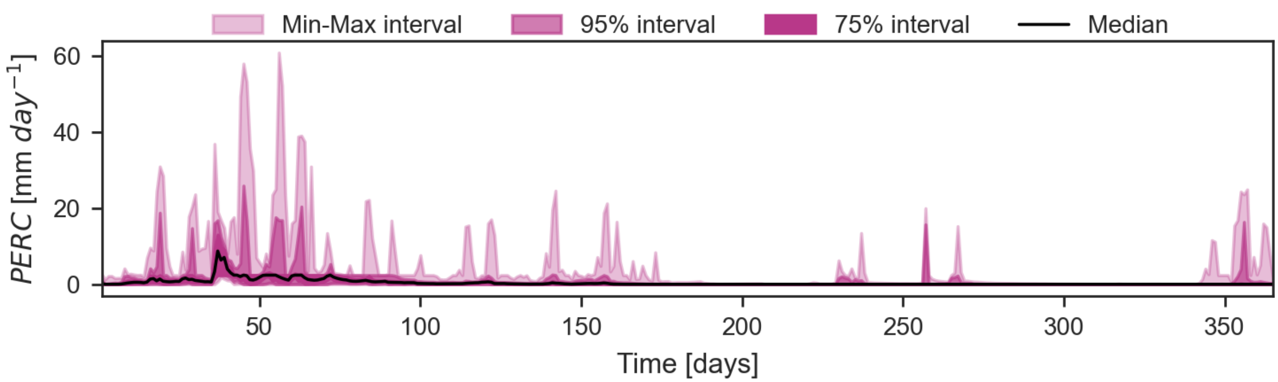


Figure S21 Time series of simulated percolation (PERC)

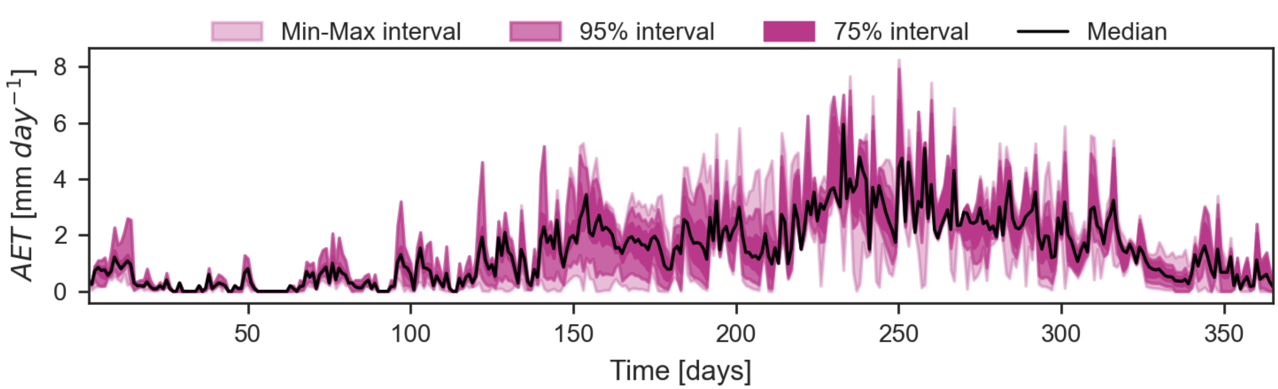


Figure S22 Time series of simulated actual evapotranspiration (AET)

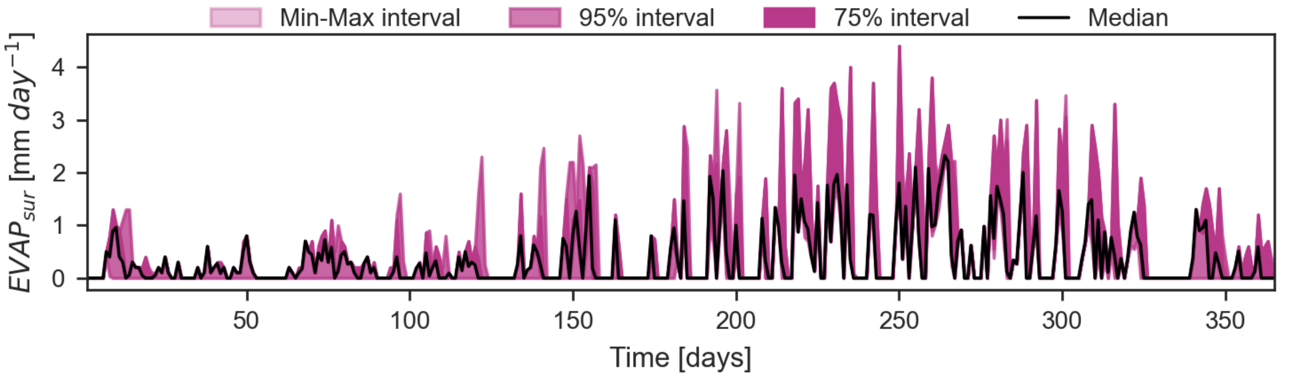


Figure S23 Time series of simulated surface evaporation ($EVAP_{sur}$; i.e. evaporation from interception storage)

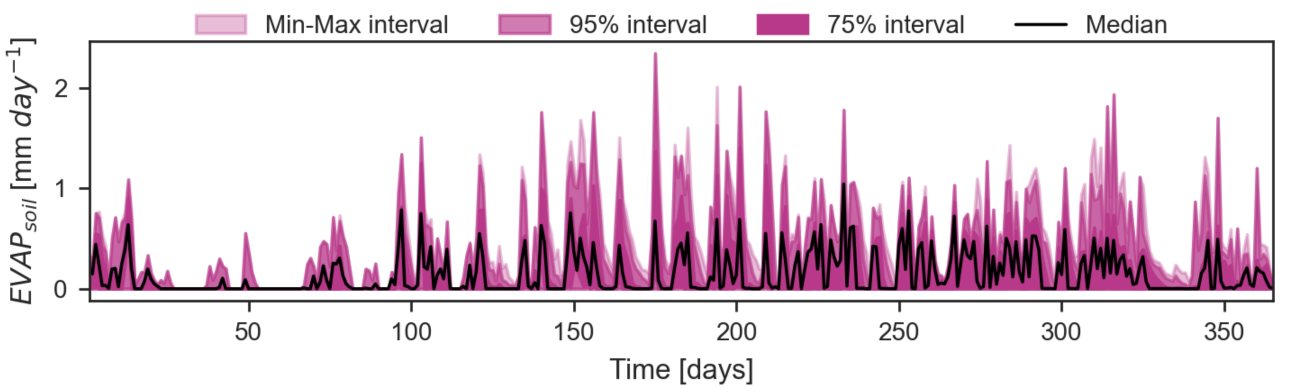


Figure S24 Time series of simulated soil evaporation ($EVAP_{soil}$)

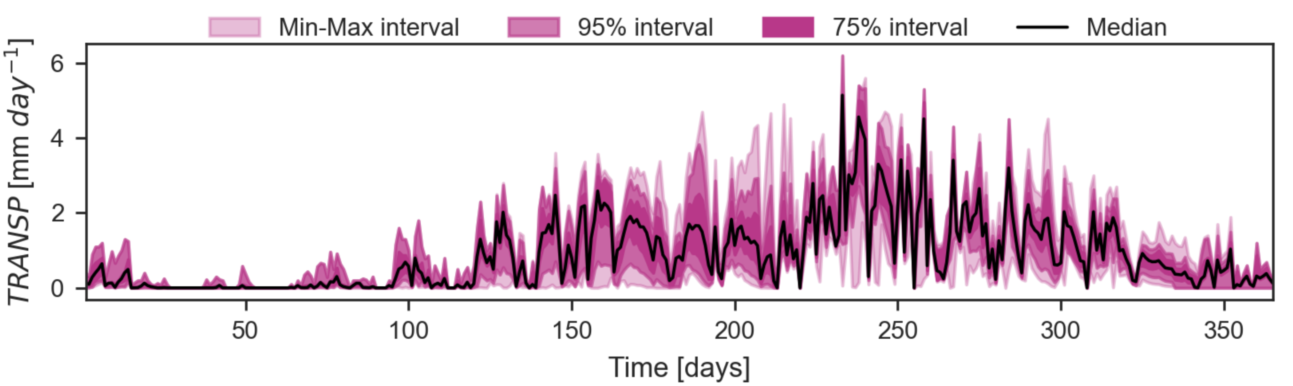


Figure S25 Time series of simulated transpiration (TRANSP; i.e. root water uptake)

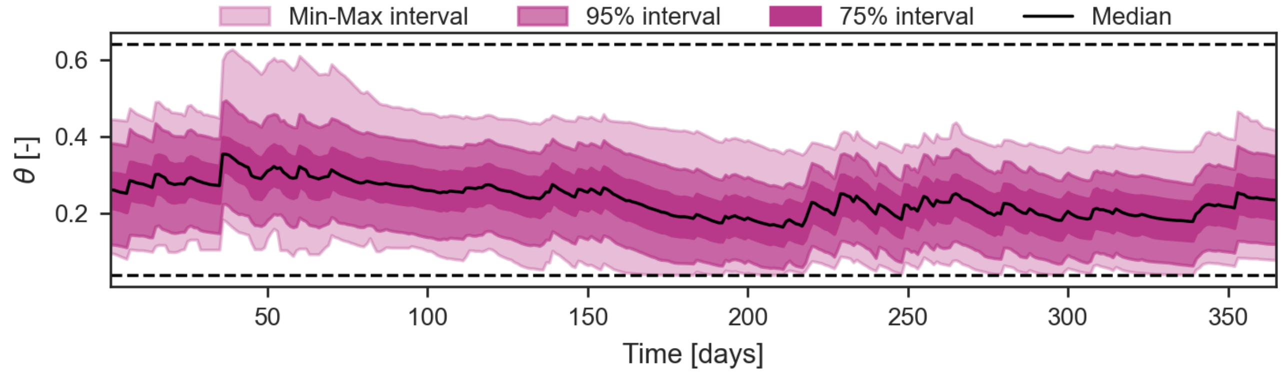


Figure S26 Trajectory of simulated soil water content (θ)

S2 Energy footprint of a notebook

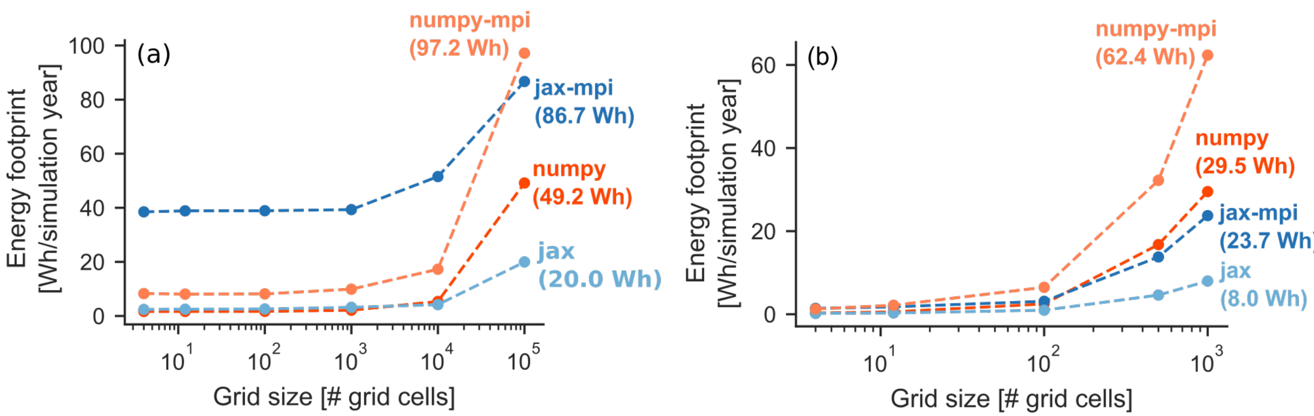


Figure S27 Energy usage of computational back-ends on a notebook for the SVAT model (a) and for the SVAT-^{18}O transport model (b)

S3 Application: Spatial distribution of meteorological data, model parameters, soil water content and median travel time of percolation

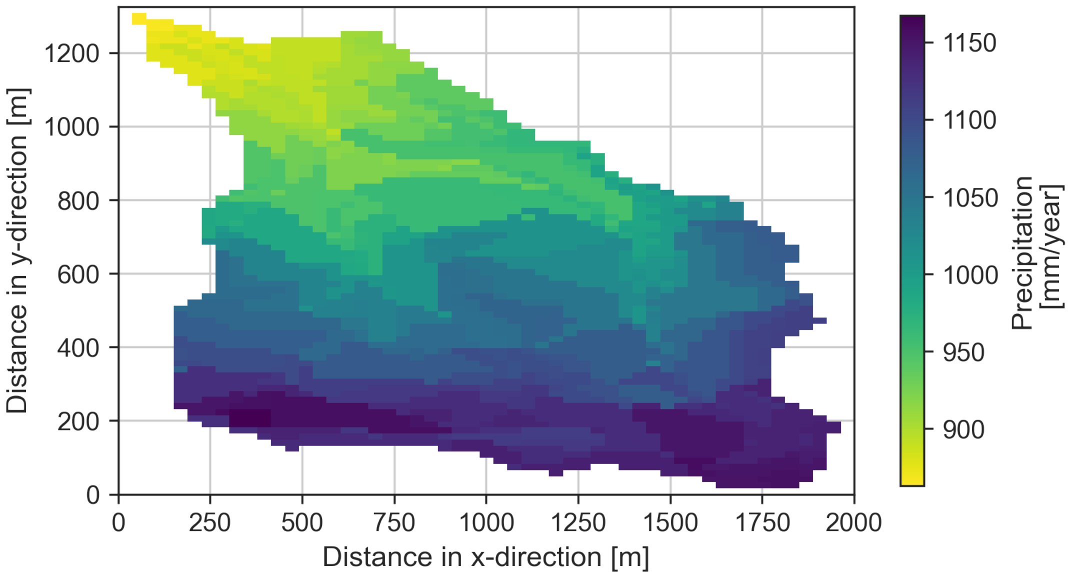


Figure S28 Average annual precipitation of the Eberbaechle catchment for the period 2019 - 2022

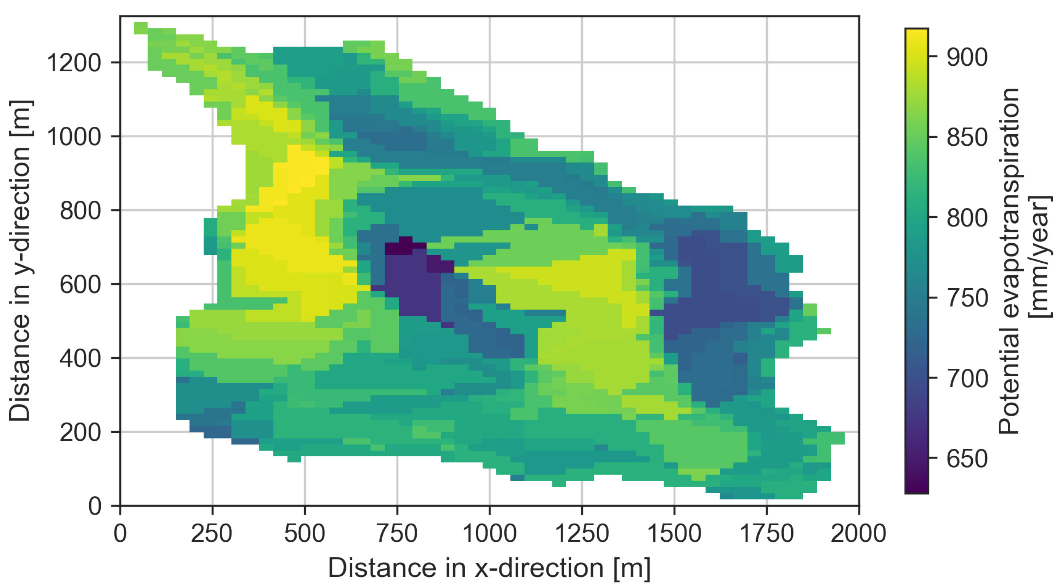


Figure S29 Average annual potential evapotranspiration of the Eberbaechle catchment for the period 2019 - 2022

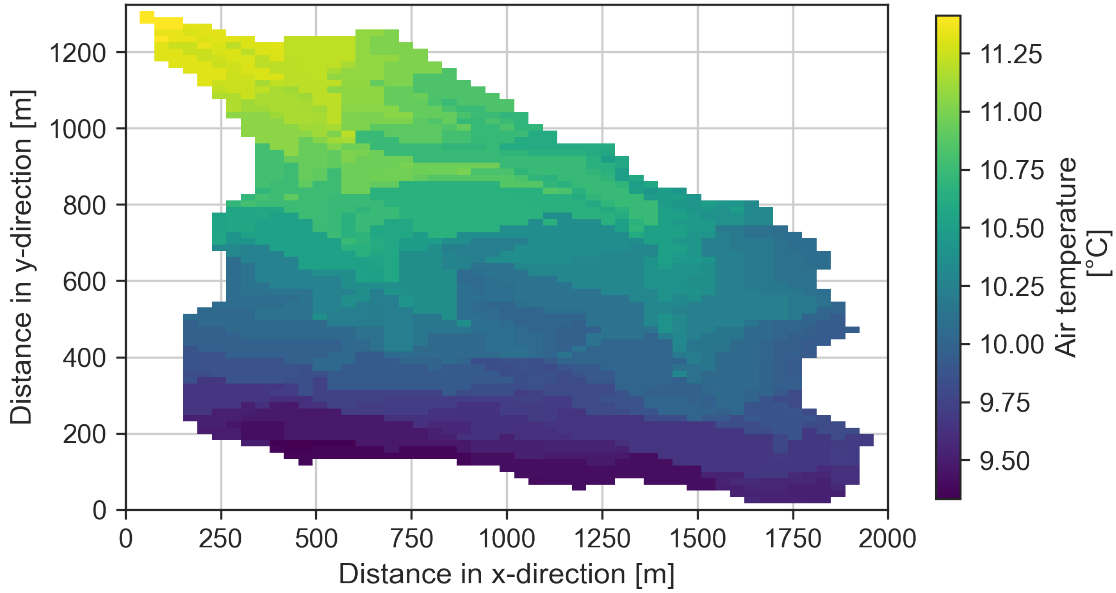


Figure S30 Average annual air temperature of the Eberbaechle catchment for the period 2019 - 2022

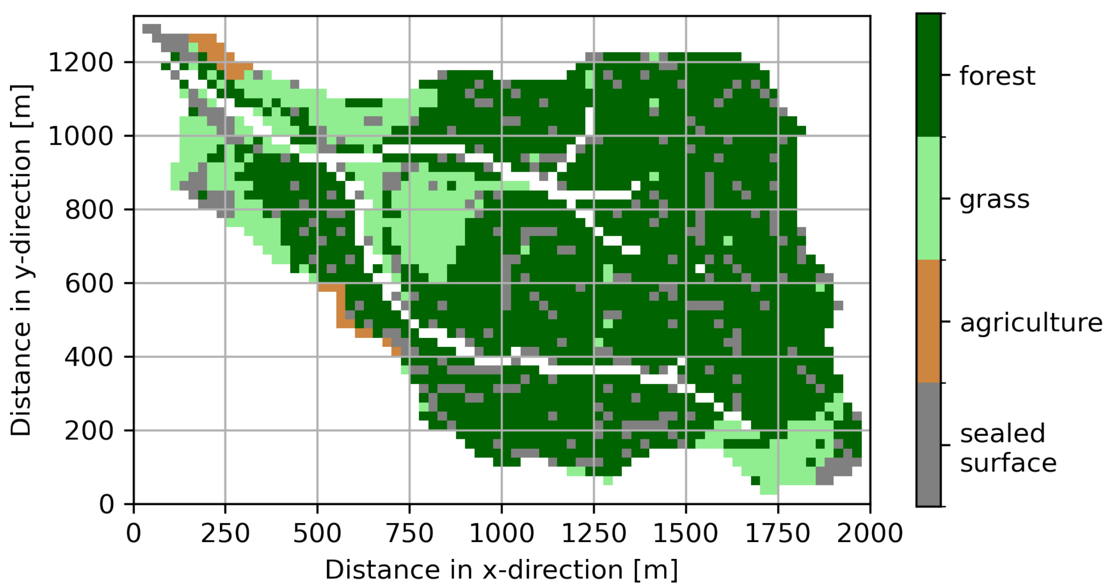


Figure S31 Land use/Land cover of the Eberbaechle catchment, Germany

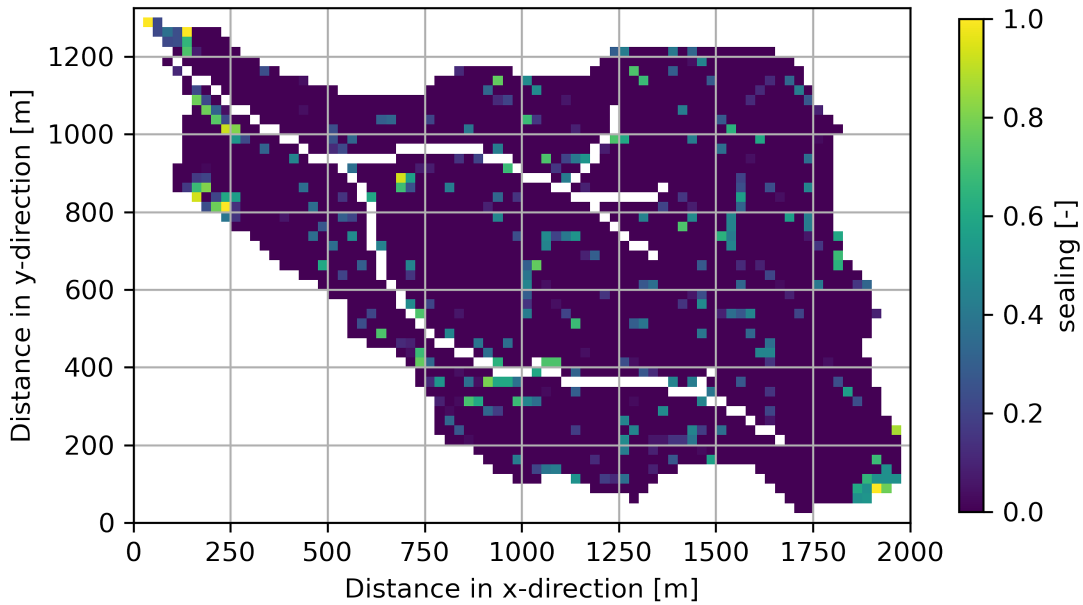


Figure S32 Surface sealing of the Eberbaechle catchment, Germany

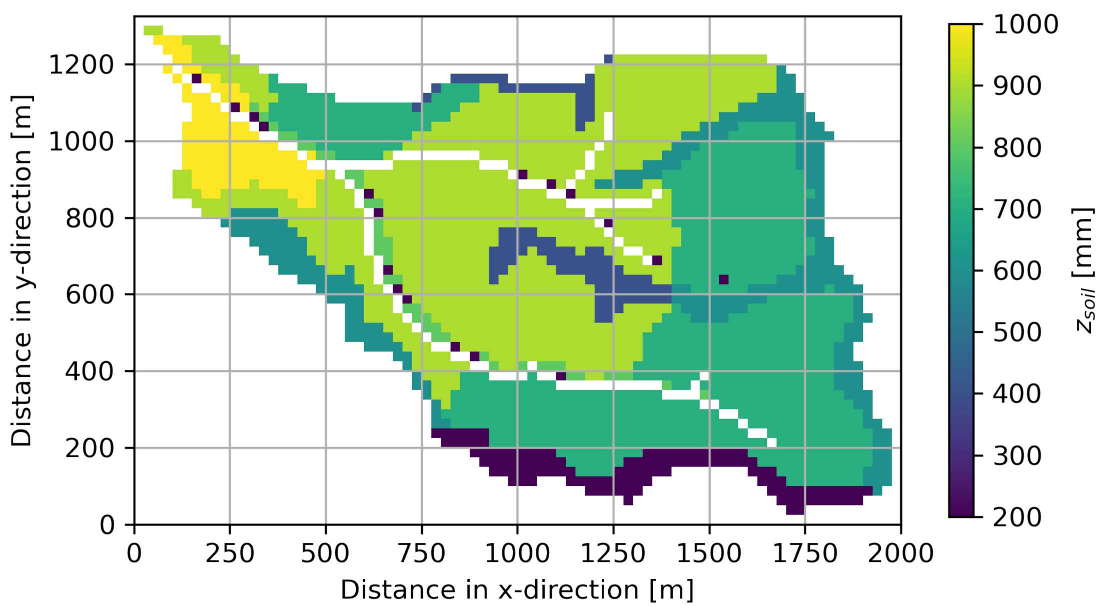


Figure S33 Soil depth of the Eberbaechle catchment, Germany

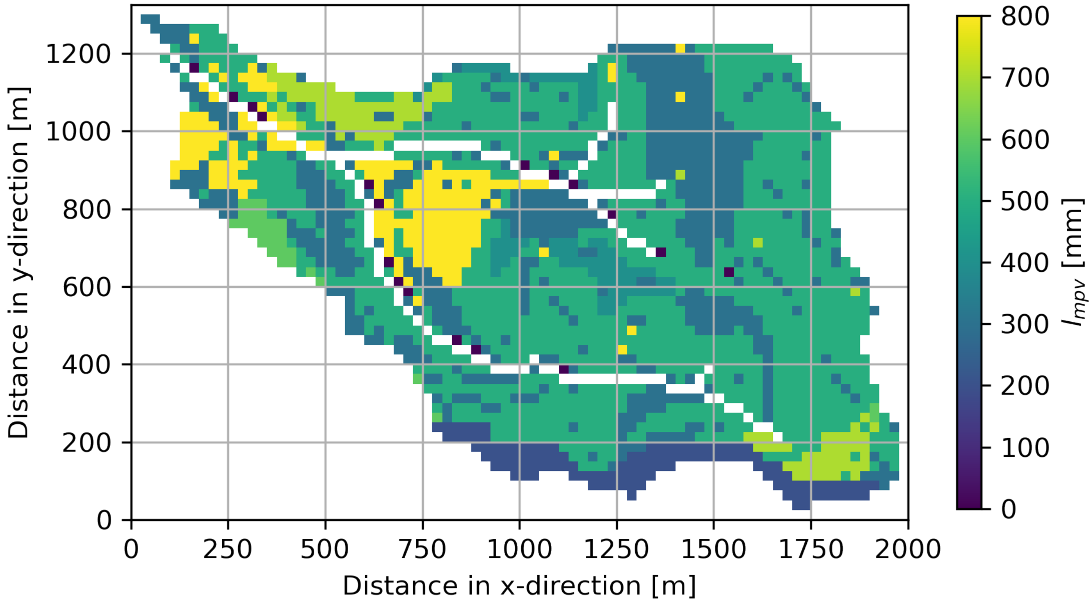


Figure S34 Length of the vertical macropores of the Eberbaechle catchment, Germany

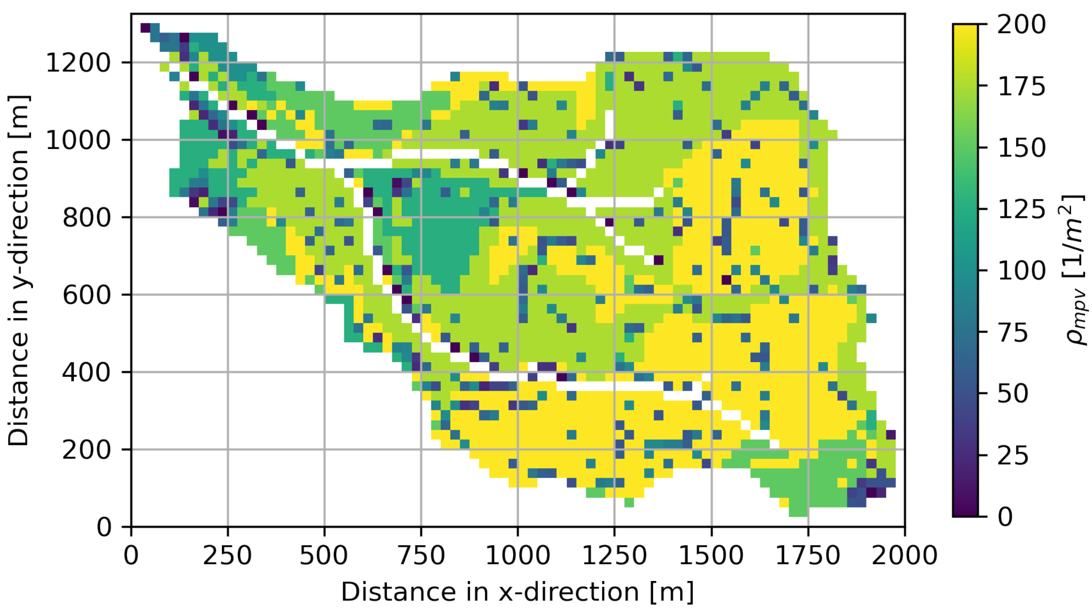
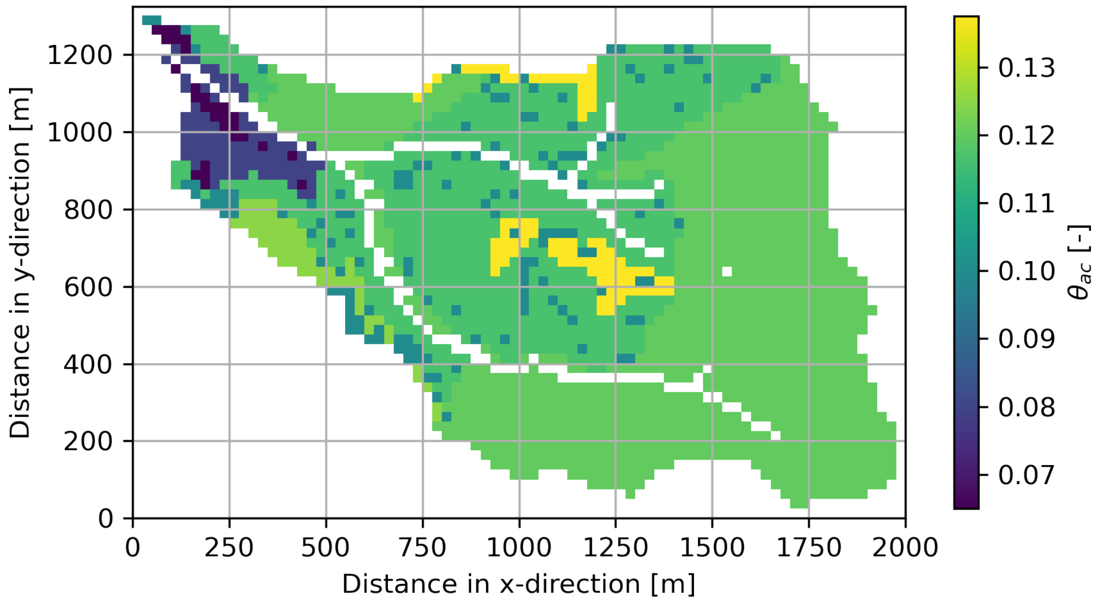


Figure S35 Density of the vertical macropores of the Eberbaechle catchment, Germany



105 **Figure S36** Soil air capacity of the Eberbaechle catchment, Germany

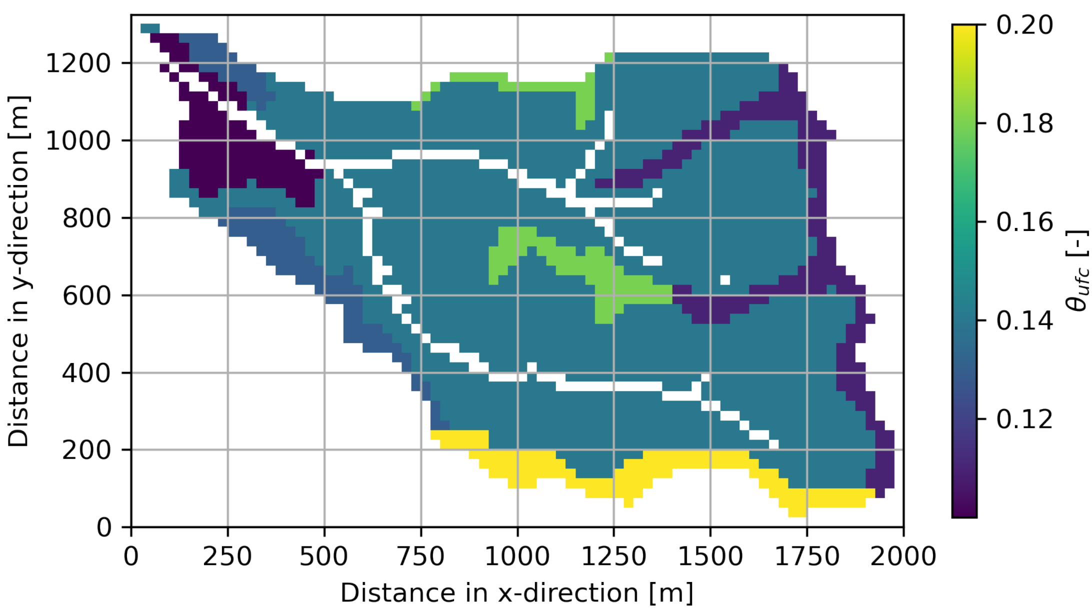


Figure S 37 Plant available field capacity of the Eberbaechle catchment, Germany

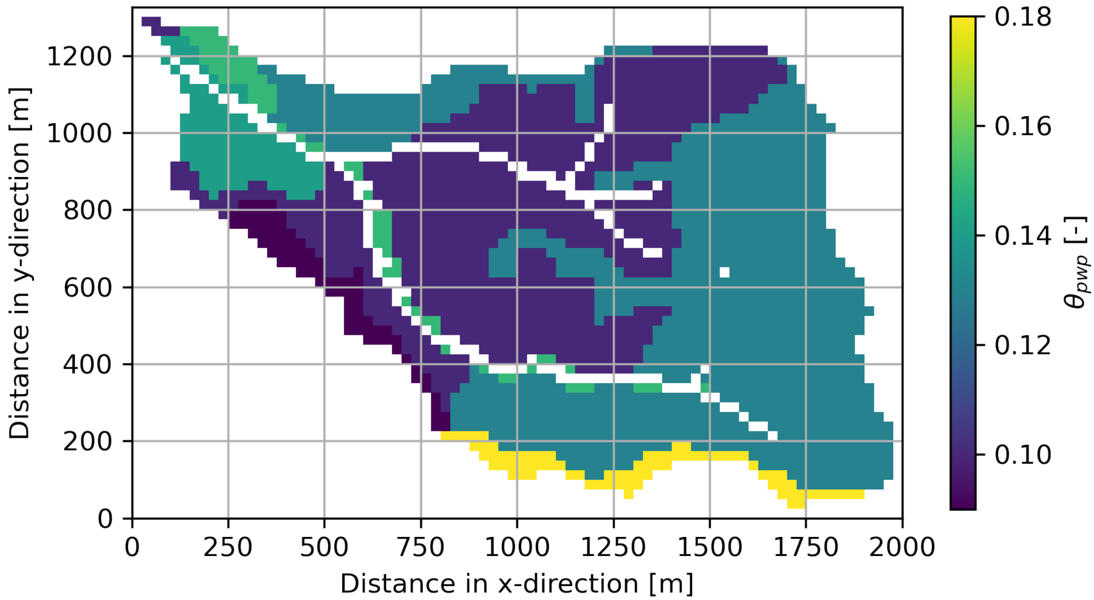


Figure S 38 Permanent wilting point of the Eberbaechle catchment, Germany

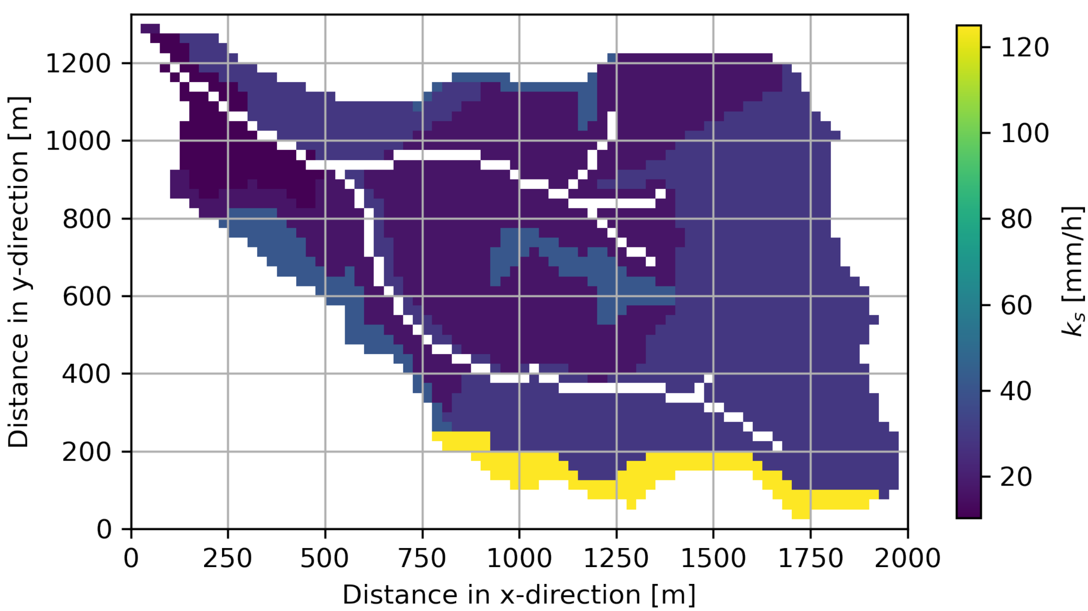


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Figure S 39 Saturated hydraulic conductivity of the Eberbaechle catchment, Germany

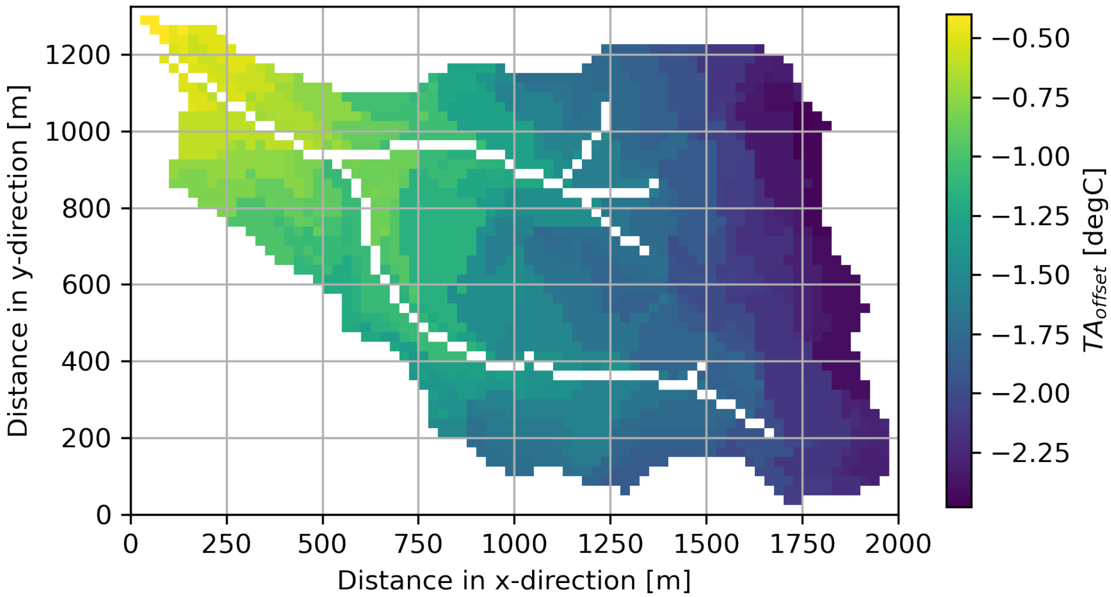
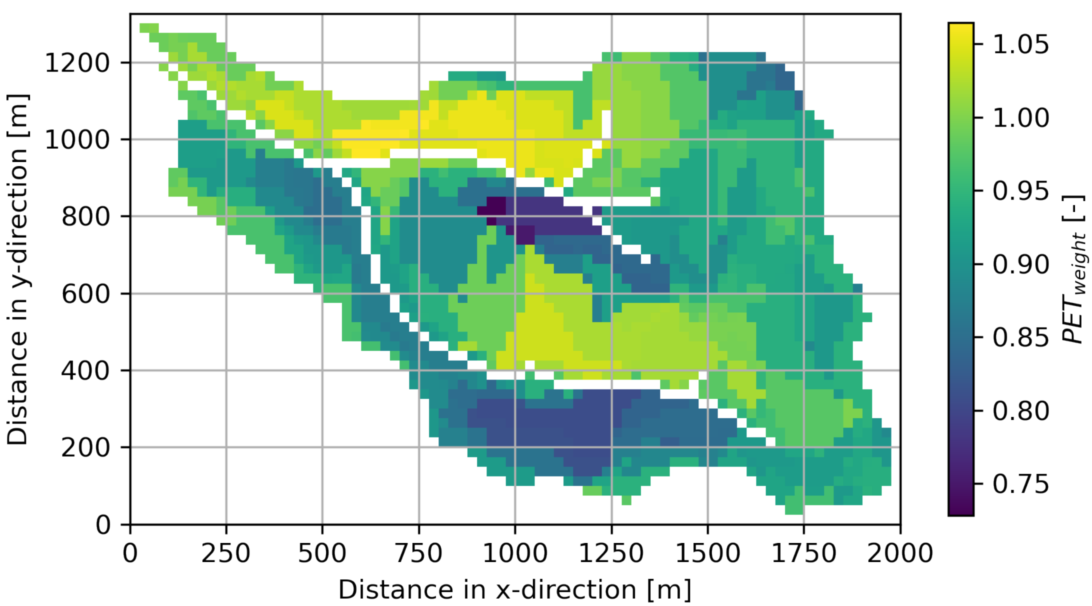


Figure S 40 Offset for air temperature of the Eberbaechle catchment, Germany



115 **Figure S 41** Weighting factor for potential evapotranspiration of the Eberbaechle catchment, Germany

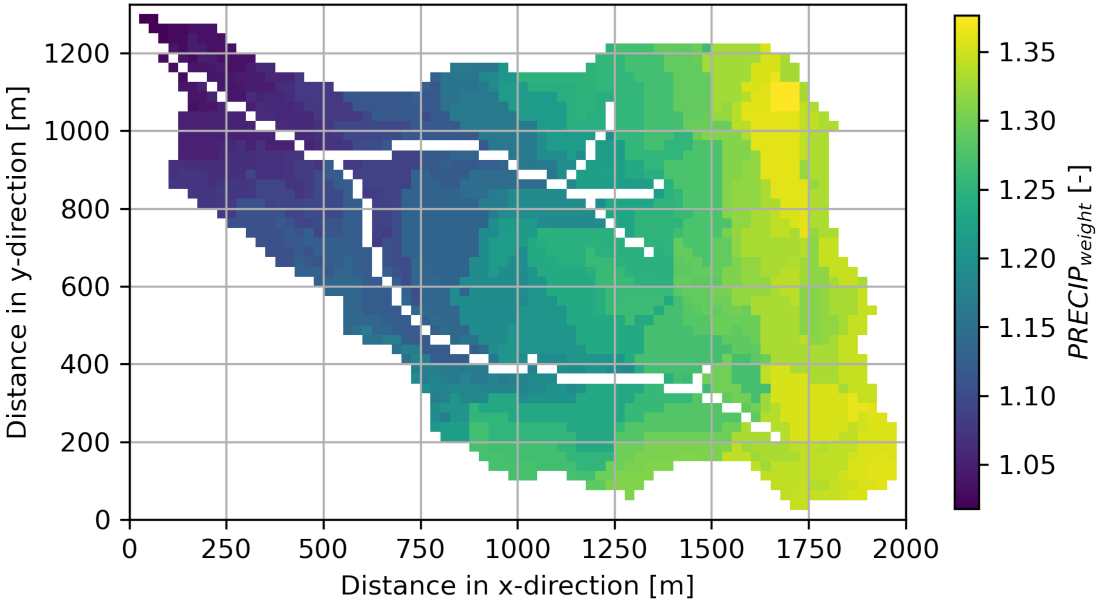


Figure S 42 Weighting factor for precipitation of the Eberbaechle catchment, Germany

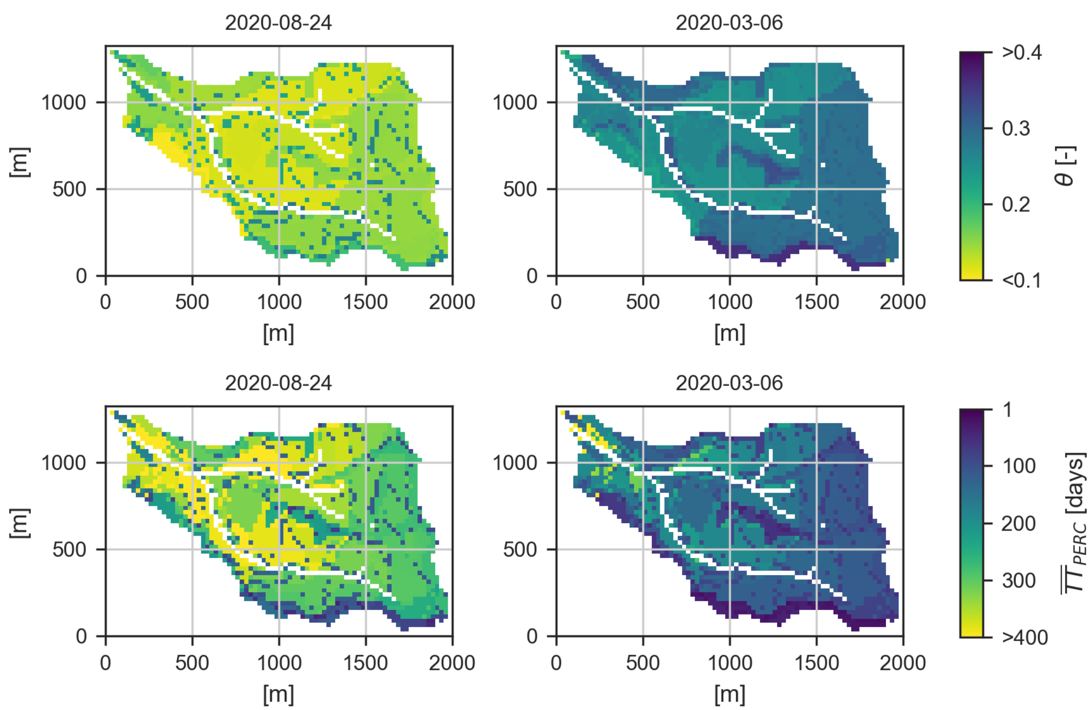


Figure S 43 Simulated soil water content (a) and median travel time of percolation (b) of the Eberbaechle catchment (1.54 km^2) at two different dates (dry and wet conditions).