Reviewer 2

Suggestions for revision or reasons for rejection (visible to the public if the article is accepted and published)

The authors have made substantial improvements; however, several issues still need to be clarified before publication.

In response to the reviewer's valuable suggestions, we substantially revised the model parameterisation and calibration procedure. Specifically, several input parameters were updated, and both the number and the parameter ranges of the calibrated variables were modified. Consequently, all simulations were repeated using the revised model setup. These changes resulted in updated water balance components, particularly groundwater recharge and actual evapotranspiration (ETa), leading to slight adjustments in some of the interpretations and conclusions presented in the manuscript. At the same time, the revised simulations show improved agreement with values reported in the literature and with independent site-specific simulations and measurements, thereby increasing the overall plausibility and robustness of the model results. All affected sections of the manuscript have been revised accordingly.

R:

L203: The authors state that they used 30 min meteorological data from ICOS stations. It is therefore unclear why daily aggregated precipitation was used for model forcing instead of the original 30 min values. This choice can substantially affect interception estimates and, consequently, throughfall and infiltration rates. This should be addressed and discussed.

A:

We thank the reviewer for this important comment. The current implementation of the LWFBrook90.jl model only accepts daily meteorological input and therefore does not allow the use of the original 30-minute ICOS meteorological data for model forcing. Consequently, daily aggregated precipitation data were used throughout this study.

We agree that the temporal aggregation of precipitation represents a limitation of the modelling approach, as it smooths short-term rainfall intensities and may affect the simulation of interception, throughfall, infiltration, and the associated soil moisture response. In particular, the use of daily aggregated precipitation input may contribute to an underestimation of rapid soil moisture increases during high-intensity rainfall events by attenuating short-term precipitation peaks. Since groundwater recharge is directly derived from the simulated percolation response, this limitation may also lead to an underrepresentation of rapid recharge pulses under such conditions. To address this concern, we have expanded the Discussion section to explicitly acknowledge and discuss this limitation.

R:

L211: The purpose of the artificial profile extension to 3 m is unclear, as is its effect on water balance components could be beyond a potential artificial attenuation of vertical fluxes. To my knowledge, numerical problems in the model are not primarily caused by short soil profiles, but rather by heterogeneous horizon sequences, which does not seem to be the case here.

A:

We agree that an extension of the soil profile up to 3 m is not generally required to ensure numerical stability and that numerical issues are more commonly associated with complex or highly heterogeneous horizon sequences than with shallow soil profiles.

Following the reviewer's suggestion, we re-evaluated the lower boundary conditions for both study sites. At the Tharandt site, the extension has been removed and the model profile is now limited to a depth of 1 m, which corresponds to the actual soil depth above the weathered bedrock. This representation is more consistent with the local site conditions and avoids introducing an artificial storage volume below the observed soil profile. At the

Kienhorst site, the artificial extension was retained. Here, the sandy soil extends well beyond the investigated profile depth and allows deep percolation. Restricting the model domain to the measured profile would introduce an unrealistic lower boundary within the unsaturated zone and could affect the simulation of vertical water fluxes. Therefore, extending the profile below the measurement depth was considered appropriate to represent the natural continuation of the homogeneous sandy substrate while maintaining realistic drainage conditions.

R:

L235: This is a useful workaround. However, since the model uses a single big-leaf concept, assigning understory LAI to the main canopy height may lead to an overestimation of ET. To verify whether ET estimates are realistic, I suggest comparing annual and/or monthly modelled ET with ICOS tower observations for both sites. A few sentences on this issue could be added to the validation section of the manuscript.

A:

We acknowledge that the use of a single big-leaf representation in LWFBrook90.jl may introduce limitations when representing vertically separated canopy layers and that assigning understory leaf area index (LAI) to the main canopy can potentially influence evapotranspiration (ET) estimates. In response to this concern, we re-evaluated the parameterisation of understory vegetation at the Kienhorst site and slightly reduced the assumed understory LAI to better reflect its contribution under the big-leaf assumption. To assess the plausibility of the resulting ET estimates, we additionally compared simulated annual ET with independent reference data. The modelled ET values are in good agreement with site-specific estimates from the Forest Environmental Monitoring Program of Brandenburg, which further supports the robustness of the applied parameterisation.

We have added a corresponding paragraph to the methods and discussion section of the manuscript, explicitly discussing the implications of the single-layer canopy representation and the comparison with observed ET data.

R:

L625: I noticed that even at the Tharandt site, soil moisture peaks in the topsoil are weak or absent in some plots. This could be related to litter-layer water storage effects (https://doi.org/10.5194/egusphere-egu26-2090). Does the model setup account for this process? This should be addressed in the discussion.

A:

We acknowledge that litter-layer water storage can play an important role in moderating near-surface soil moisture dynamics, particularly in forested systems and may contribute to dampening or delaying topsoil moisture responses to precipitation events. In the current model setup, an explicit litter layer was not implemented. Instead, the soil column was discretised into three mineral soil layers and litter processes were therefore implicitly included within the uppermost soil layer. We agree that this represents a simplification and may limit the ability of the model to explicitly resolve short-term storage and release processes occurring in the litter layer.

However, incorporating a separate litter layer is not feasible within the present modelling framework without substantial restructuring of the soil profile parameterisation. Importantly, the overall agreement of simulated water balance components (including generall soil moisture dynamics, evapotranspiration, and groundwater recharge) with independent measurement-based estimates, and site-specific simulations suggests that the omission of an explicit litter layer does not introduce systematic bias at the temporal and spatial scales considered in this study.

We have added a corresponding statement in the discussion section to explicitly acknowledge this limitation and to clarify its potential implications for near-surface soil moisture dynamics.

R:

Tables S1 and S2: Please discuss why maxlai and glmax were not included in the calibration, whereas cvpd was. In addition, if the MvG parameters were measured or fitted, it is unclear why such broad calibration ranges were assigned to them. This also needs to be discussed.

A:

In response, we revised the calibration strategy to improve parameter identifiability and reduce equifinality within the stomatal conductance formulation of the model. The parameter glmax was included in the calibration because it directly controls the upper boundary of canopy conductance and has a big influence on transpiration dynamics, making it sensitive and identifiable from soil moisture and evapotranspiration signals. The cvpd parameter was retained in the calibration because it governs the stomatal response to atmospheric vapour pressure deficit and cannot be constrained directly by independent site measurements. As this physiological response is site-specific and has a pronounced influence on evapotranspiration and soil moisture dynamics, calibration was considered appropriate.

The maximum leaf area index (maxlai) was not included in the calibration procedure, as it is strongly constrained by independent site-specific observations from ICOS measurements and phenological data (Weis et al., 2023). Given the availability of these external data sources, allowing maxlai to vary during calibration would have introduced unnecessary degrees of freedom without improving model identifiability. Instead, maxLAI was fixed to measured seasonal maxima to ensure physical consistency of canopy structure representation.

Regarding soil hydraulic properties, we clarify that the Mualem–van Genuchten parameters were not directly measured but derived from site-specific particle size distributions using established pedotransfer functions according to Wösten et al., 1999. In contrast, saturated hydraulic conductivity (Ksat) was estimated based on the results of sieving analysis according to Hazen, 1892. To better reflect the uncertainty associated with pedotransfer-based parameter estimation, the initial calibration ranges for the MvG parameters were revised and substantially narrowed compared to the original setup.