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Modelling water balance components in a temperate forest in Germany: A comparative analysis of pine, oak, and beech

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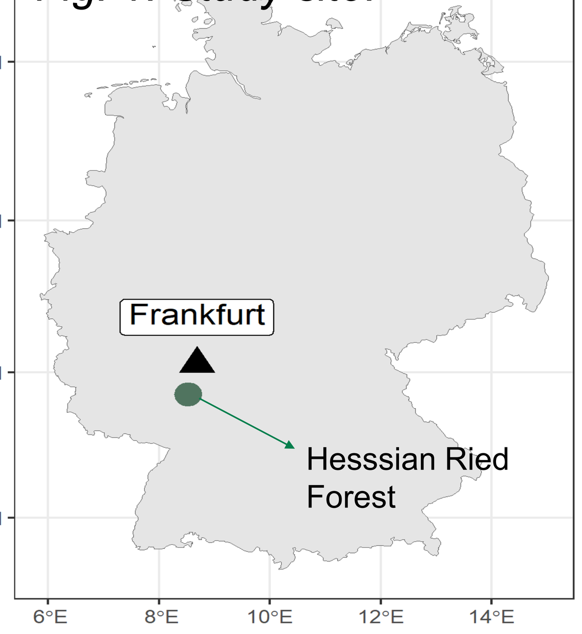
Introduction

The **Frankfurt Rhine-Main metropolitan region** is heavily dependent on groundwater, with the Hessian Ried forest being one of the main sources.

Fig. 1. Study site.

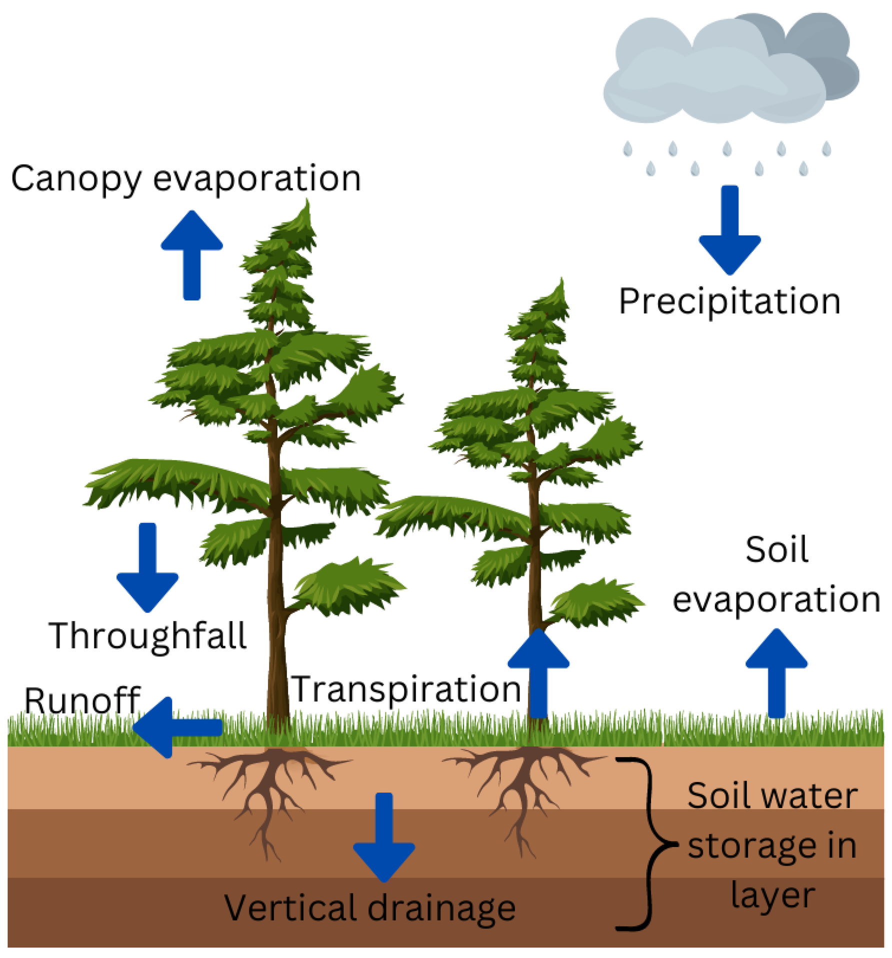


Factors such as climate change, population growth and irrigation expansion have increased the **pressure on water resources**, exacerbating conflicts over water use. Therefore, comprehensive solutions for a sustainable and flexible water management need to be developed.

Aim of the study

To assess the **impact of tree species and soil physical properties on water dynamics in the Hessian Ried forest** by modelling the water balance components in three representative monitoring plots (pine, oak and beech).

Methods



We used the **LWF-Brook90R package** for the implementation of the LWF-Brook90 1D-model. The input data included daily climate variables, vegetation and soil physical parameters at different depths down to 2 m. The study period was from 2005 to 2022.

Fig. 2. Water balance components simulated in LWF-Brook90.

Parameter sets

- Default: all the input parameters included in LWF-Brook90, except for annual leaf and stem area index.
- WHH-KW: tree species-specific parameters suggested in the report "Standortsfaktor Wasserhaushalt im Klimawandel" (Weis et al., 2023).
- Calibrated vegetation and soil parameters: obtained from a Bayesian analysis (Schmidt-Walter et al., 2020).

Additionally, we performed a sensitivity analysis for each plot by means of a Monte Carlo filtering.

For validating, we compared the model result to throughfall measurements and soil water content observations at different depths.

Results

The largest water flux variations were observed at the beginning of the season (April and May) for deciduous trees. Interception fluctuated greatly in the pine plot.

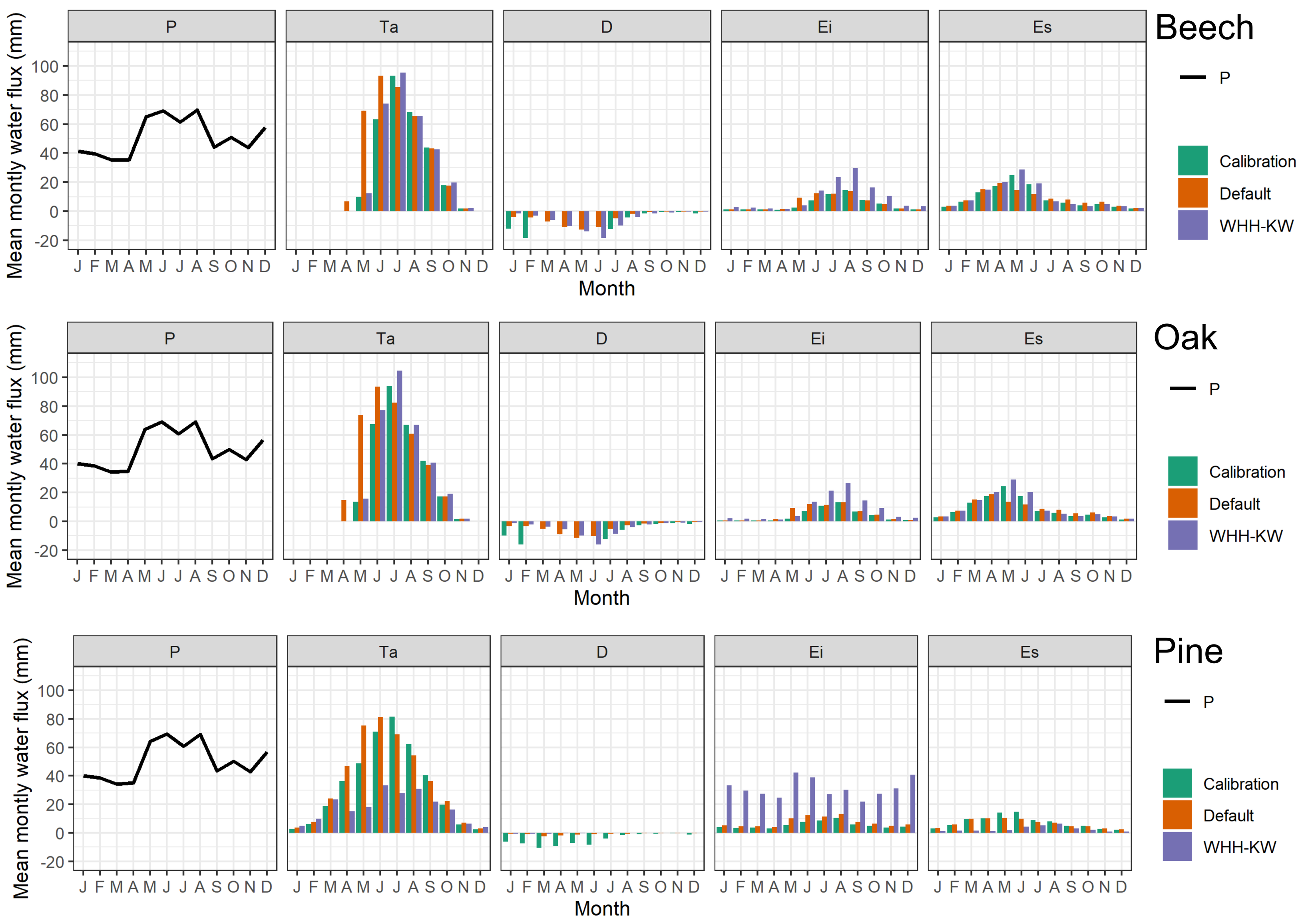


Fig. 3. Water balance components as monthly mean values.

We obtained a good agreement between results and observed daily throughfall. However, the calibration did not improve the simulations in all cases.

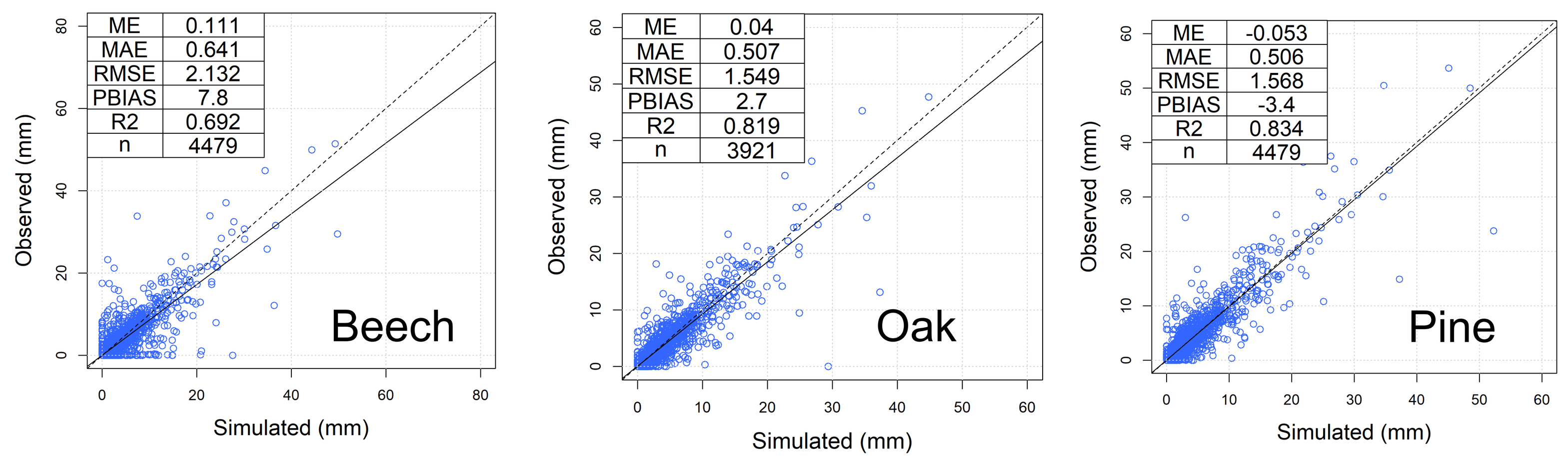


Fig. 4. Throughfall after calibration.

We achieved a more comprehensive and improved estimation of soil water content after calibrating the soil physical parameters, such as saturated hydraulic conductivity and residual water content.

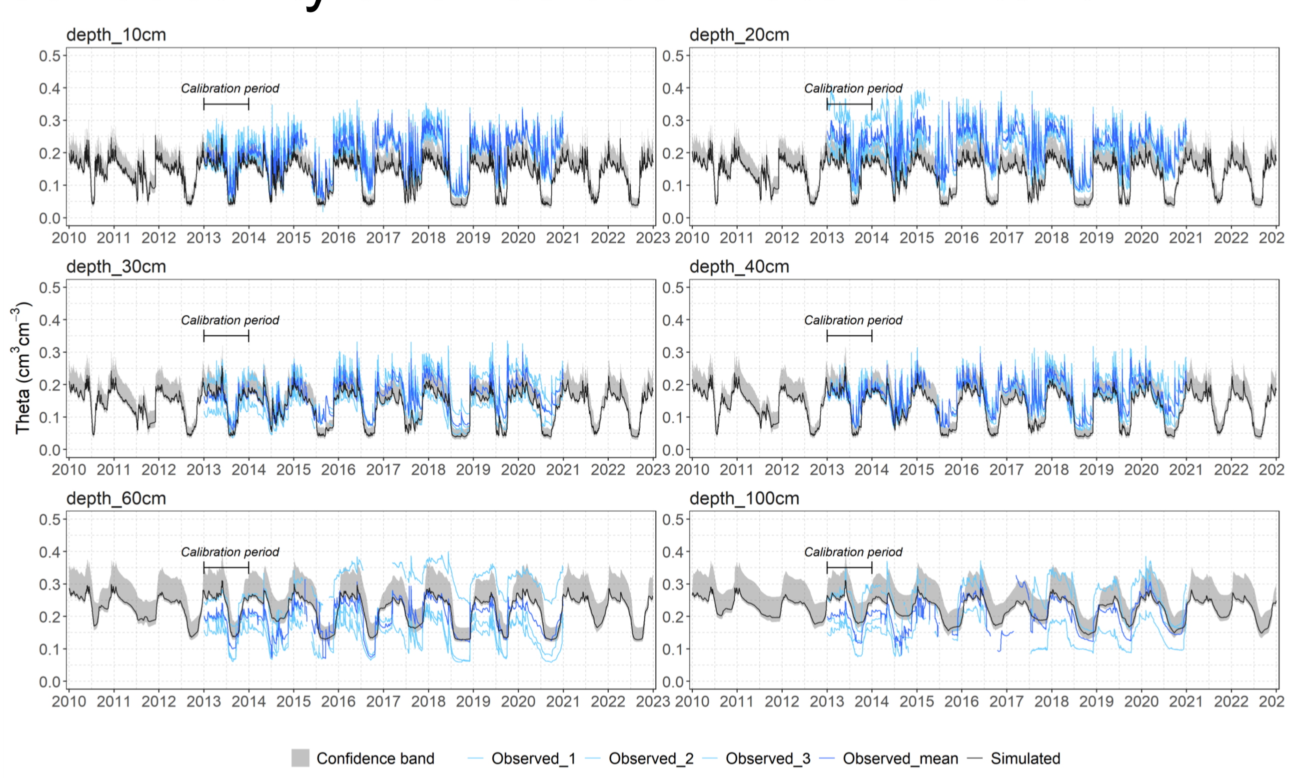


Fig. 5. Soil water content at different depths in the Beech plot after calibration.

Conclusion

Our findings highlight the importance of site- and species-specific model parameterization in forests, as well as the consideration of uncertainties for soil water content simulations. The results contribute to water resources management in diverse forested landscapes.

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Wasser: N
LURCH Grundwasser nachhaltig bewirtschaften
WaRM Wassersystemmodell Rhein-Main