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Quantifying the effects of urban vegetation on water partitioning in complex cityscapes – The potential of isotope-based ecohydrological models

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Related presentations:
Kuhlemann et al. EGU2020-160
Marx et al. EGU2020-414
Yang et al. EGU2020-333

Take home message

An isotope-based ecohydrological model can inform us about the impact of different types of urban green on key water flux and storage dynamics. This knowledge is valuable for challenging questions like urban heat island effect and groundwater recharge in an urban setting.

Background

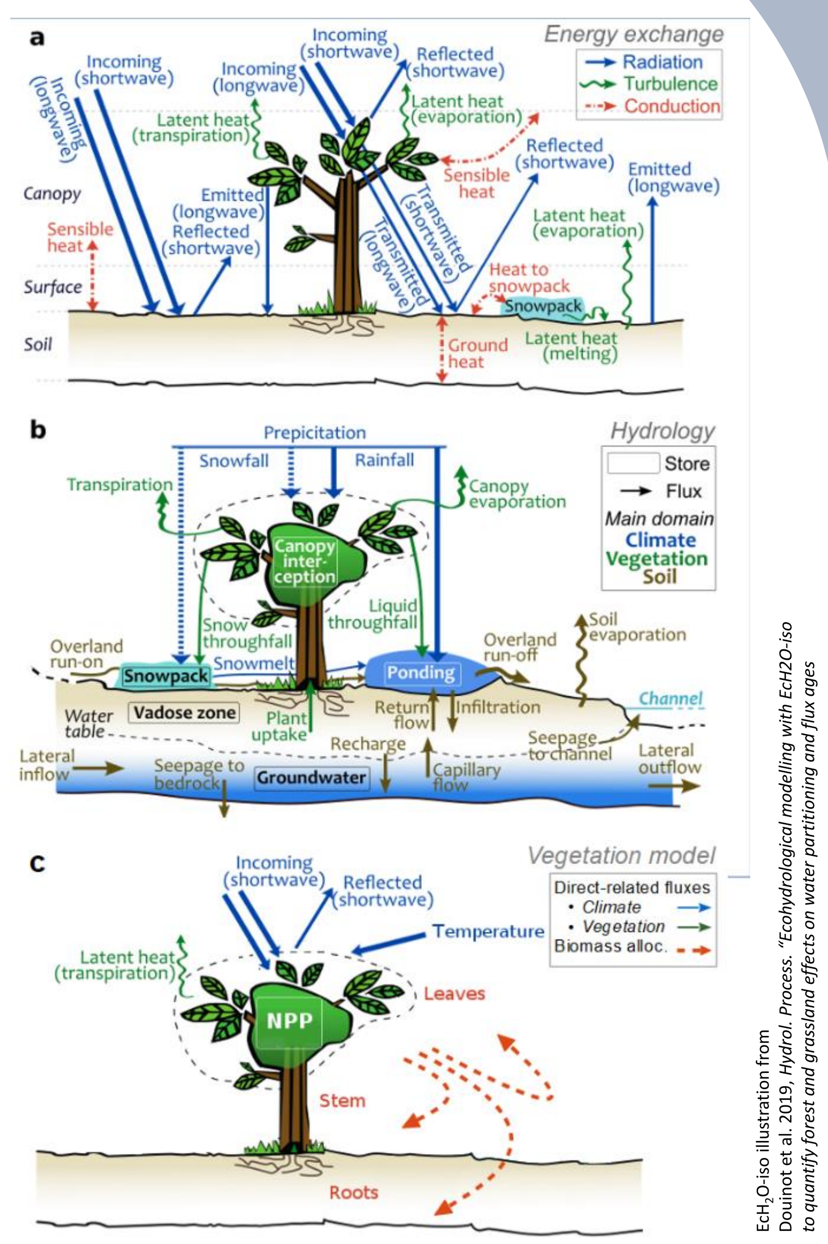
Little is quantitatively known about how different types of **urban green spaces** (lawns, parks, woodland etc.) regulate the partitioning of evaporation, transpiration and groundwater recharge. To address this crucial issue, we integrated field observations with advanced, **isotope-based ecohydrological modelling** at the plot scale in the urban area of Berlin, Germany. Measurements of soil moisture, sap flow, and stable isotopes in precipitation, soil water and groundwater have been made over the course of one growing season.

Study site Berlin Steglitz

- TU Berlin field site in Steglitz, southern Berlin*
- Three types of urban green: **Trees, shrub** and **grass**
- Data collected on **soil moisture, sap flow**, and stable water **isotopes** in **precipitation**, **soil water** and **groundwater** since 2019
- On-site eddy flux tower collects hydroclimate data since 2018. Climate data from DWD station Dahlem and eddy flux tower at TU main campus complement this data

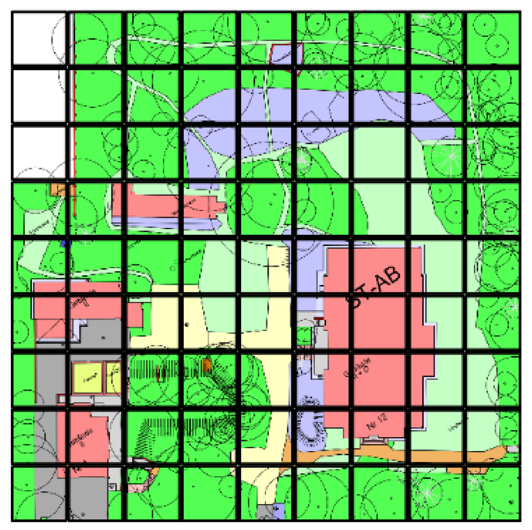
The model EcH$_2$O-iso

- Process-based, tracer-aided ecohydrological model
- Quantifies **stable isotope ratios** and **water ages** in various stores (e.g. soils, groundwater) and fluxes (evaporation, transpiration and recharge)
- Has been used to describe effects of different vegetation covers on **water partitioning**, but never before in an urban setting
- **Goal**: Describe, quantitatively, water partitioning processes and changes in water ages by different types of **urban greens**
- Plot scale (step 1, this presentation) and 10 km² scale (step 2)



Spatial resolution: 10 m²

Temporal resolution: 1 h

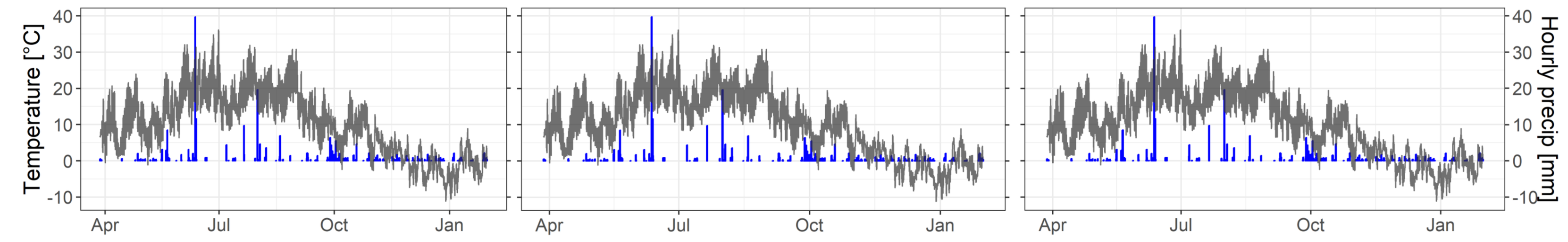


* The study site (Latitude: 52.457232 and Longitude: 13.315827) is located in the garden of the Institute of Ecology and belongs to the Urban Climate Observatory operated by the Chair of Climatology at TU Berlin.

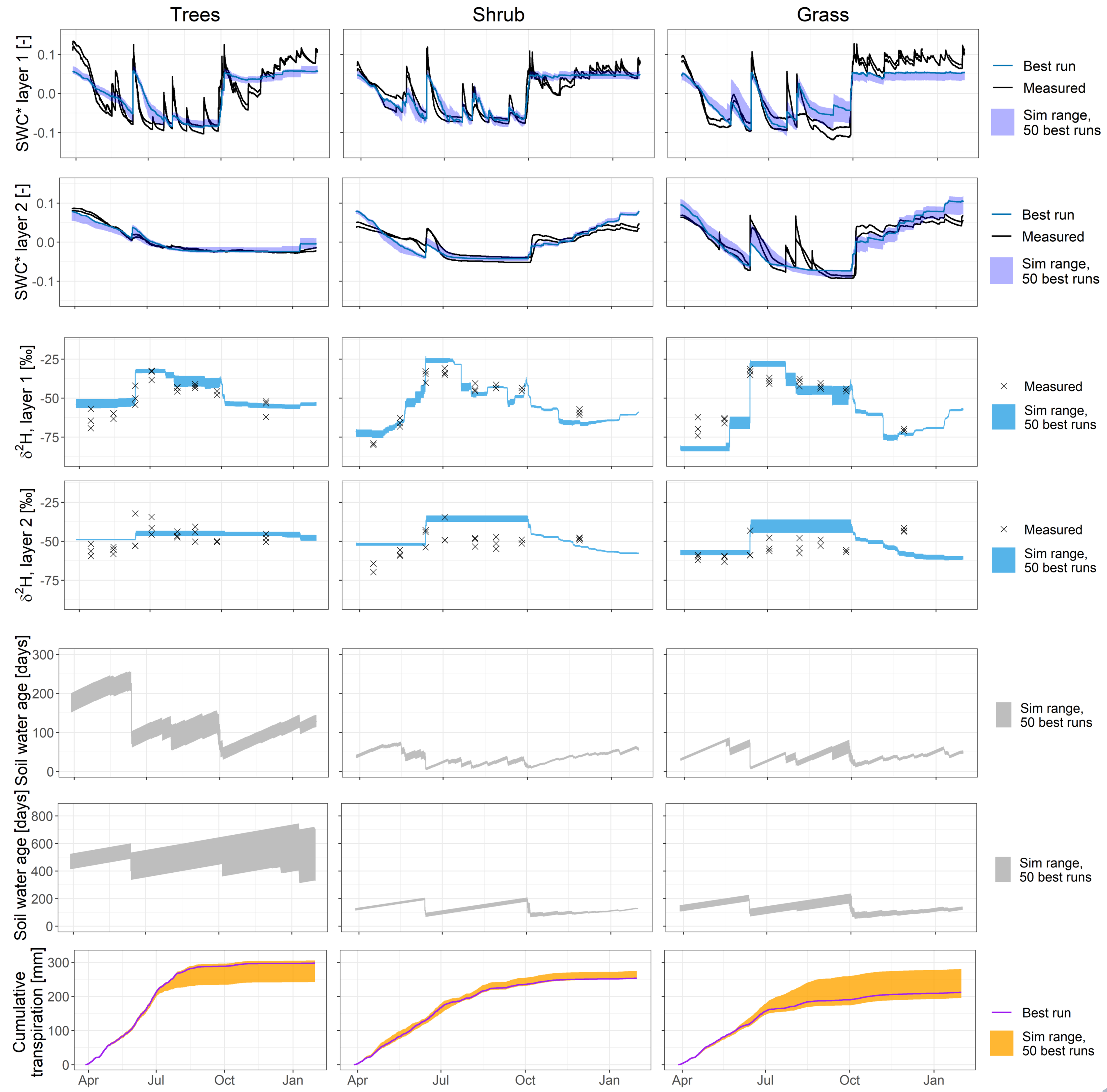
Results

- The soil water content dynamics are captured well in both layers. SWC* is the normalized soil water content calculated by: SWC* = SWC – mean(SWC)
- The simulated δ²H isotopes fit well to the measured ones in both layers.
- Only the simulated SWC* results are calibrated using measured values. The isotope values are used as a validation, increasing the likelihood of getting the right results for the right reasons.
- The age of the soil water is larger under trees than under shrub and grass. This could be explained by a higher interception capacity and lower soil evaporation.
- Transpiration increases in order grass < shrub < trees.

Climate input



Simulations



Conclusion

The results, which form the basis for **future upscaling**, show that urban green spaces play an important role in urban hydrology and in Berlin there is a trade-off between moderating the **urban heat island effect** and maintaining **groundwater recharge**. Consequently, it is clear that **vegetation management** needs to be considered in sustainable water and land use planning in urban areas to build **resilience** in cities to climatic and other environmental change.

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