Highly resolved investigation of the interception process

Research focus: Canopy Drainage

Sandra Grunicke, Ronald Queck, Christian Bernhofer

06.05.2020

BE 1721/23-1

Outline

1. The CanWat model as a tool: concept and drainage approach
2. Example calculation for a single tree
3. Measuring site and equipment
4. Research questions

1. The Canopy Water Balance Model (not published yet)

Numerical Model

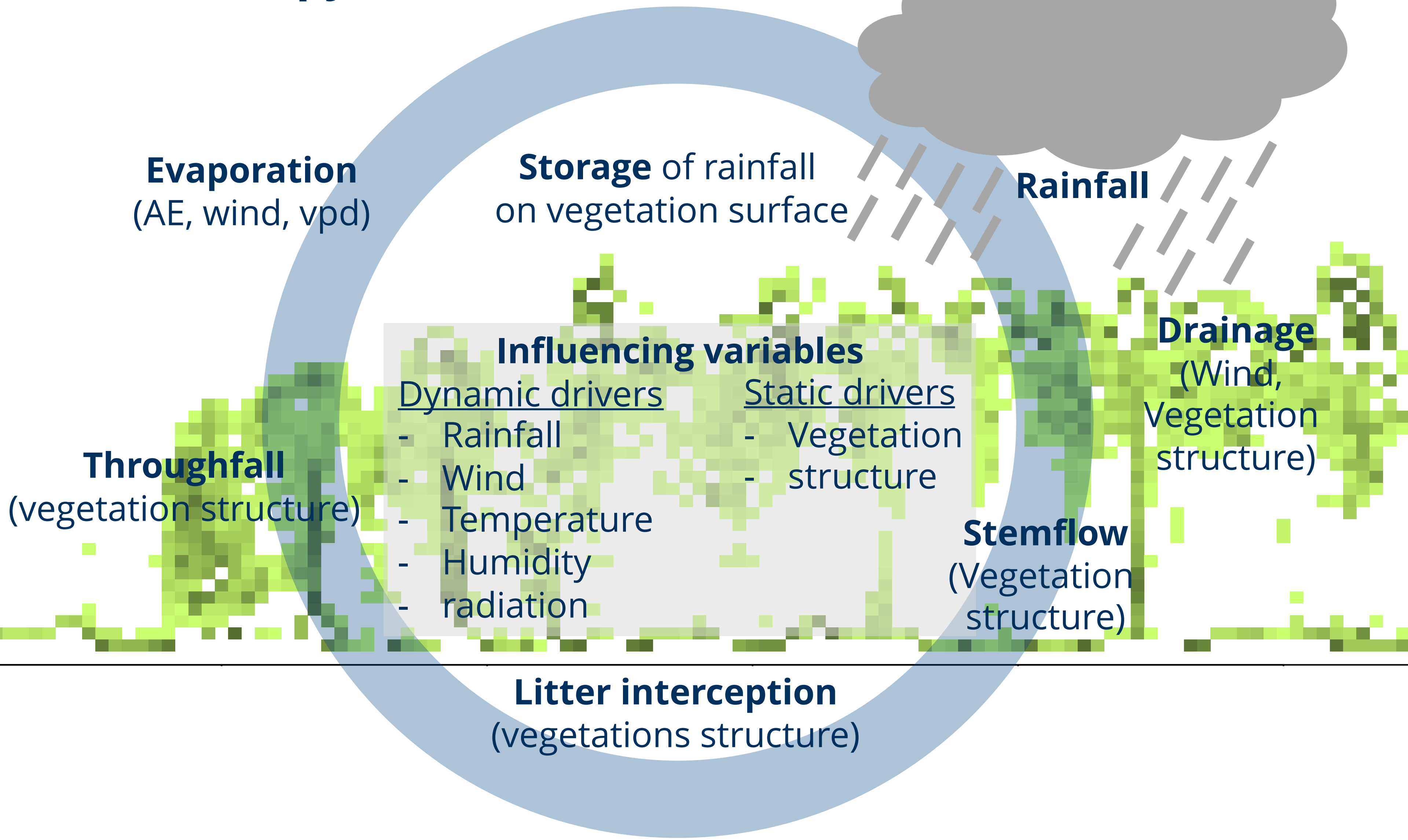
Requirements

- flexible tool for investigation of interception process
- interactive work with source code
- high spatial resolution
- long time-series
- large areas

Realisation

- diagnostic model: driven by measured data
- Modular structure in R: modification of subroutines
- Scalable : identic parameters for each resolution
- Variable time-steps: 1 s – 3600 s
- Numerical solution of differential equation: Runge-Kutta approach of 4th order

1. The Canopy Water Balance Model



1. The Canopy Water Balance Model

Governing equation

$$\frac{dC}{dt} = (P - T - E - D)/\Delta t$$

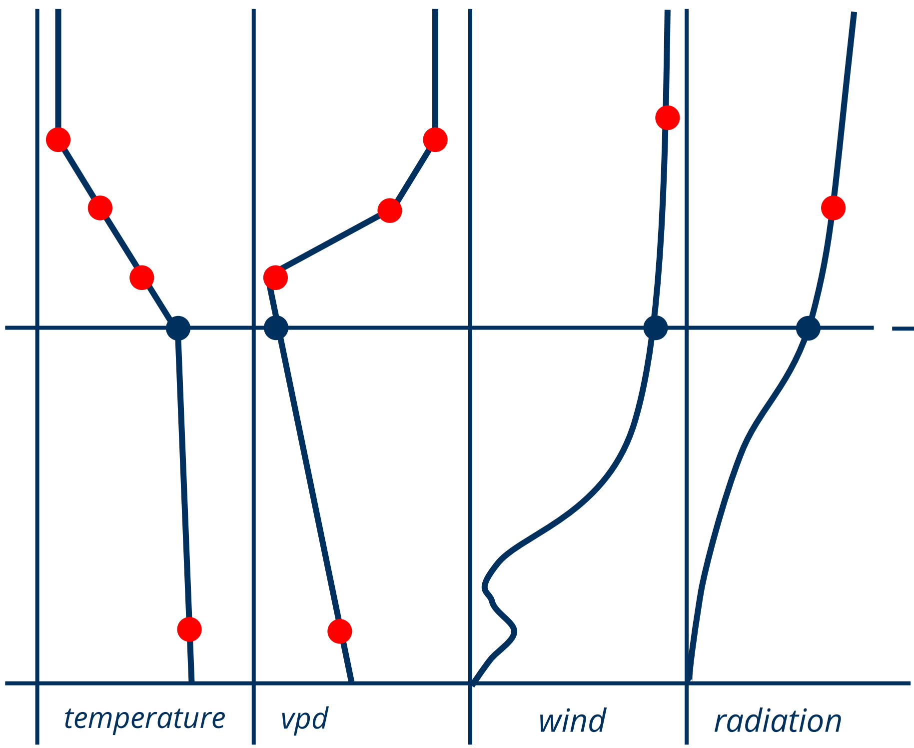
C… storage, t… time, Dt … length of measuering interval
P… brutto precipitation, T … throughfall, E… evaporation,
D… Drainage

$$\frac{dC}{dt} = P_i(1 - p_T) - E_i(C) \; - a \cdot e^{b\cdot(C-S)} + \sum_z D_{z,i-1}(1 - p_{T,z})$$

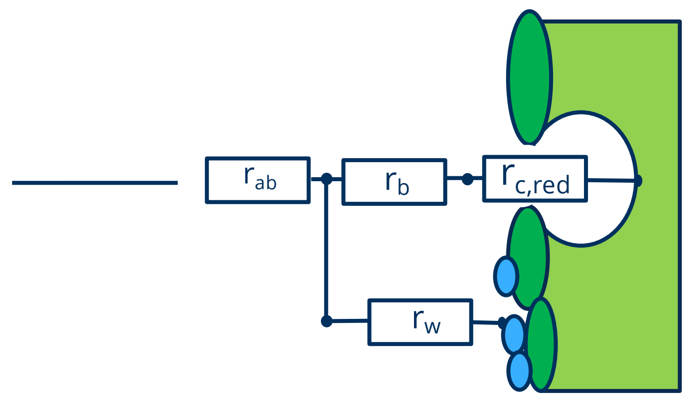
pT … throughfall coefficient, S… storage capacity
A defines drainage in case of C-S=0

1. The Canopy Water Balance Model

Meteorological conditions as profiles and

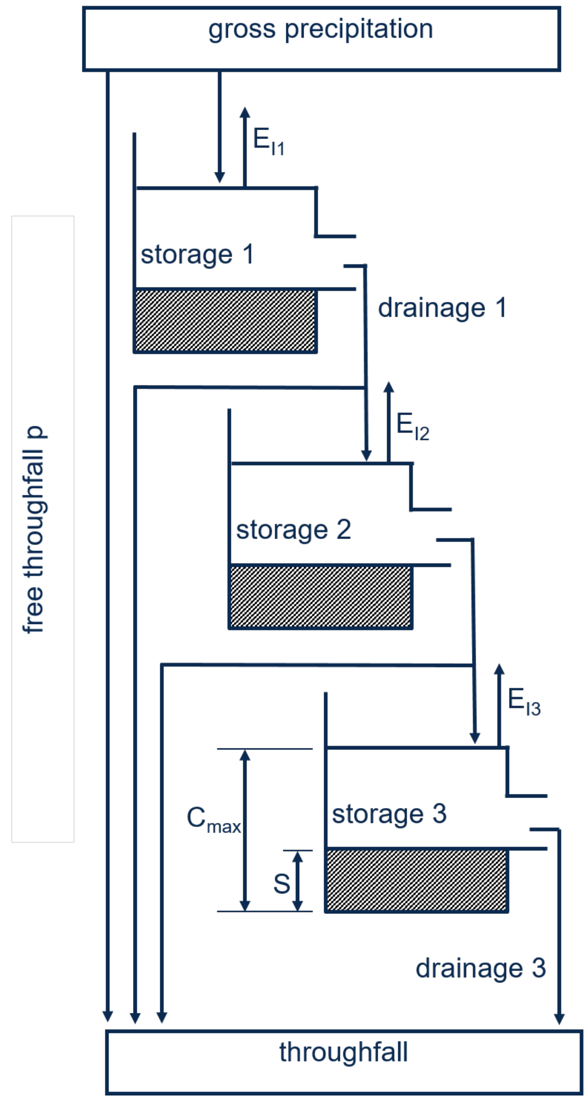


Evaporation (Penman-Monteith Resistance network)



1. The Canopy Water Balance Model

Storage cascade with single linear storages after Rutter *et al.* (1971)

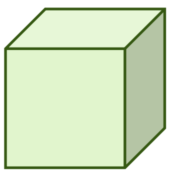


1. The Canopy Water Balance Model

Storage parameters and scaling

$$D = Dmin_1 \cdot e^{b_1 (C - S_1)}$$

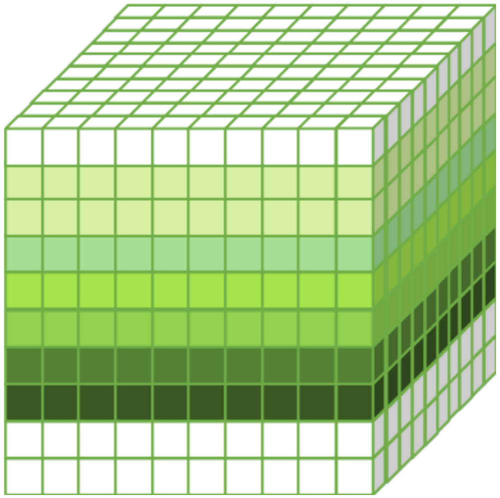
D in mm/min



$$Dmin = \frac{Dmin_1}{S_1}$$

$$b = \frac{b_1}{S_1}$$

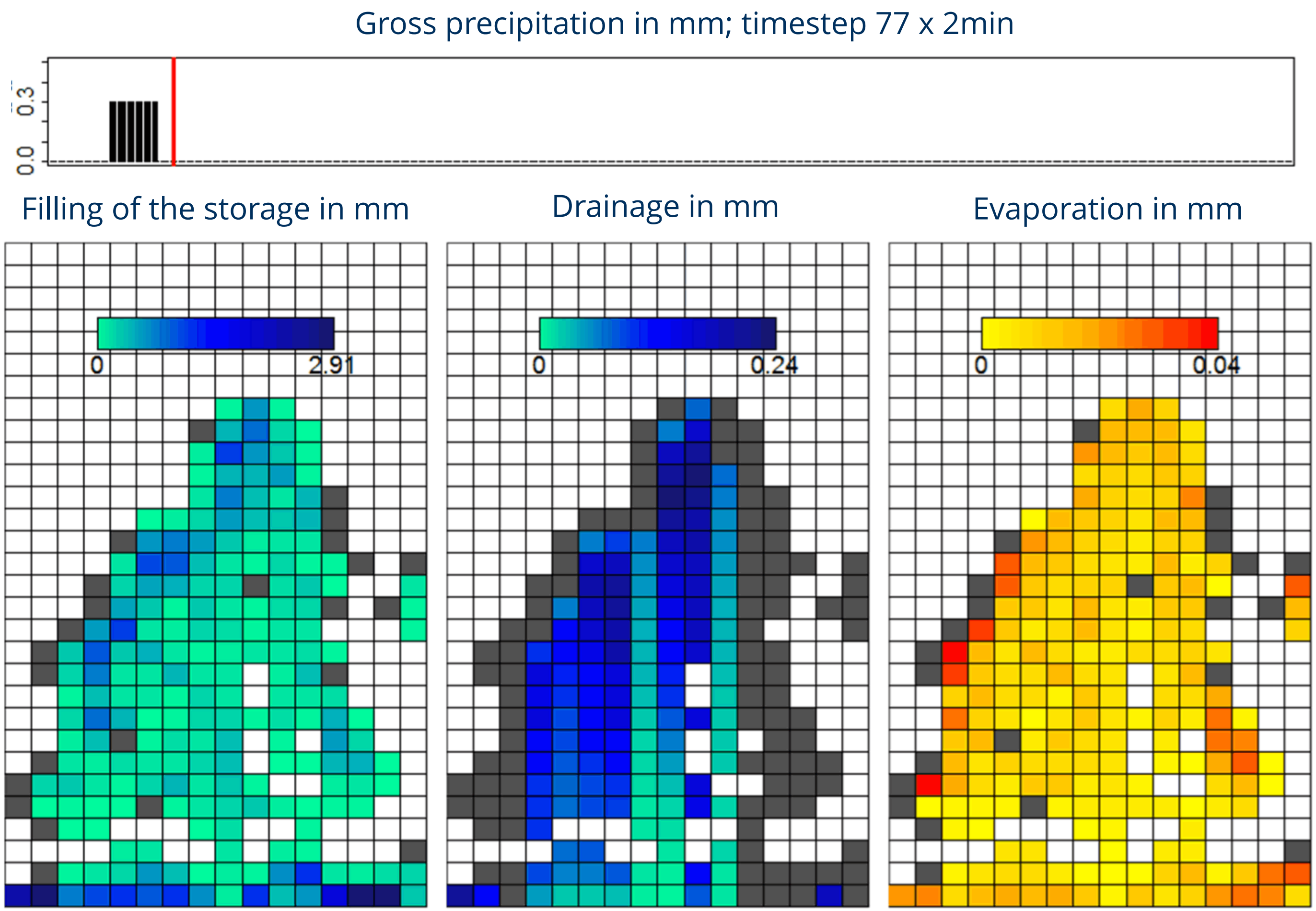
$$S = S_1 \cdot \frac{PAD}{PAI}$$



$$D = S \cdot Dmin \cdot e^{\left(b \cdot \frac{C - S}{S}\right)} / 60$$

D in mm/s

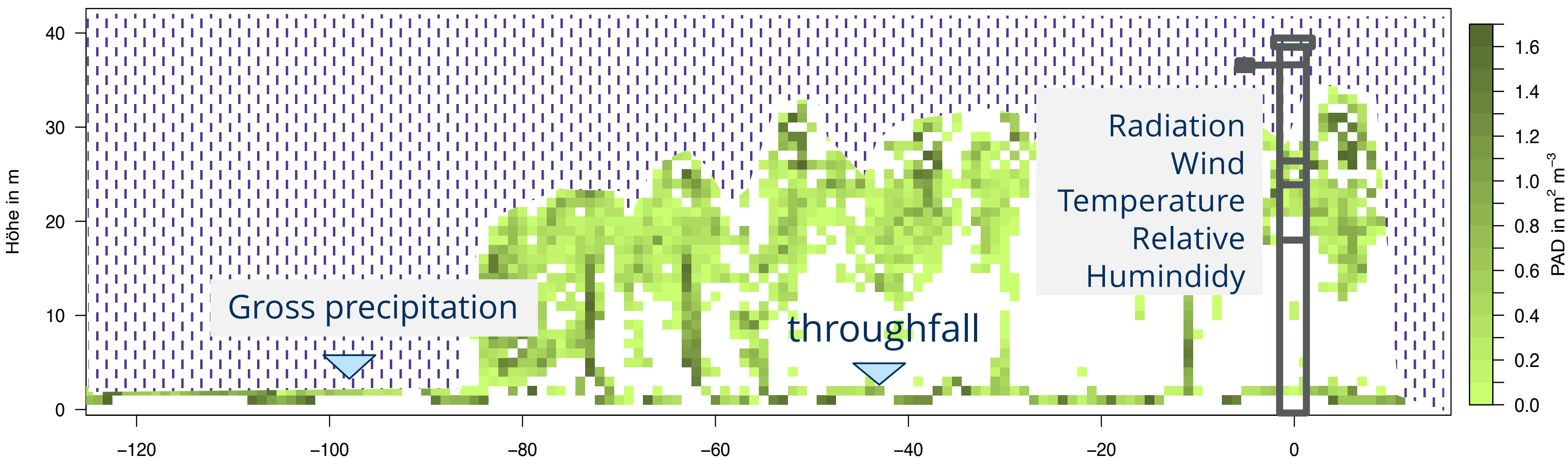
2. Example Calculation for a single tree



Example calculation: Bulk rainfall for a single tree

3. Measuring site: Anchor Station Tharandter Wald

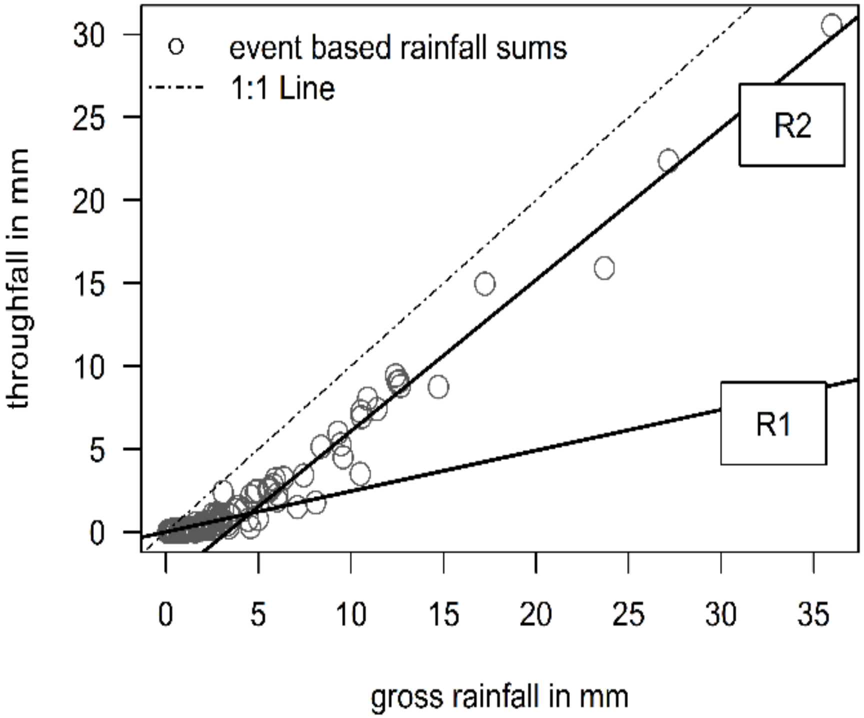
Static drivers	Dynamic drivers	
Vegetation model from terrestrial laser scans, 1m³ resolution	Gross precipitation from nearby clearing Throughfall meausurements (gutters)	Radiation Wind Temperature Relative Humidity From measuring tower

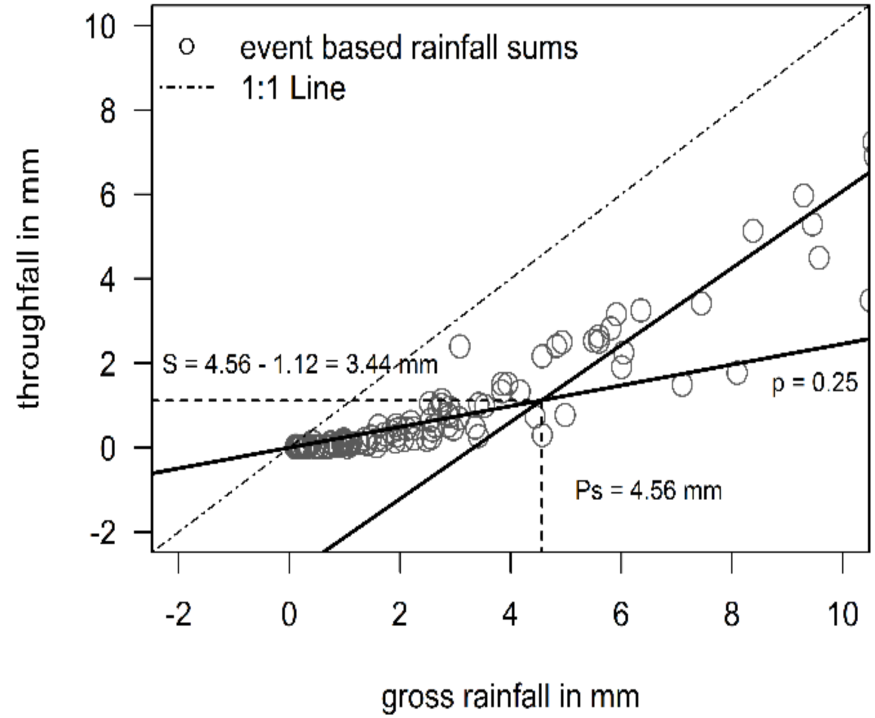


3. Measuring site: Anchor Station Tharandter Wald

Canopy parameter derivation: Regression analysis based on relation between throughfall and gross rainfall for the stand

S… storage capacity, Ps… canopy saturation point, p … throughfall coefficient





Left figure: complete data set with two regression lines, right figure: enlarged cutout of same data set with focus on intersection point

4. Research questions

Research Focus: Drainage

1. Many models (Aston, 1979; Vrugt et al., 2003) use the exponential drainage approach by Rutter et al. (1971) or similar approaches (Massman, 1983). How viable are exponential approaches?

   - Using rainfall and throughfall data from the stand, the CanWat model will be calibrated with canopy parameters derived from measurements of the site
   - Validation of the currently implemented exponential approach (Rutter 1971) with data from the throughfall gutters

4. Research questions

Research Focus: Drainage

2. How is drainage described in other interception models? Are there better alternatives to the exponential approach or improved versions?

- Testing drainage approaches from literature e.g. drip equations given in Návar (2019)
- Development of combined or new approaches to describe drainage
- Calibration and validation for the stand

3. In reality, drainage most likely occurs before saturation of the canopy is reached. Can this effect be implemented in interception models and is it a viable attempt to improve the description of the drainage process?

References

Aston, A.R., 1979. Rainfall interception by eight small trees. J. Hydrol. 42, 383–396. https://doi.org/10.1016/0022-1694(79)90057-X

Massman, W.J., 1983. The derivation and validation of a new model for the interception of rainfall by forests. Agric. Meteorol. 28, 261–286. https://doi.org/10.1016/0002-1571(83)90031-6

Návar, J., 2019. Modeling rainfall interception components of forests: Extending drip equations. Agric. For. Meteorol. 279, 107704. https://doi.org/10.1016/j.agrformet.2019.107704

Rutter, A.J., Kershaw, K.A., Robins, P.C., Morton, A.J., 1971. A predictive model of rainfall interception in forests, 1. Derivation of the model from observations in a plantation of Corsican pine. Agric. Meteorol. 9, 367–384. https://doi.org/10.1016/0002-1571(71)90034-3

Vrugt, J.A., Dekker, S.C., Bouten, W., 2003. Identification of rainfall interception model parameters from measurements of throughfall and forest canopy storage. Water Resour. Res. 39, 1251. https://doi.org/10.1029/2003WR002013

Sandra Grunicke
Institute of Hydrology and Meteorology,
Chair of Meteorology
Sandra.Grunicke@tu-dresden.de

Acknowledgement: This project is supported by the Deutsche Forschungsgemeinschaft DFG BE 1721/23-1 Interzeption.