Actual evaporation from bare soils - A comparison of numerical modelling and field lysimeter data

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1 Introduction

- The dynamics of evaporation is influenced by the atmospheric conditions.
- Predicting evaporation under limited water supply conditions, where water transfer to the atmosphere is limited primarily by soil hydraulic properties (SHP), is challenging.
- The parametrization of the SHP differ by accounting capillary and non-capillary processes.
- There are different methods to determine the parameters of SHP, e.g., pedotransfer funcion, lab or in-situ measured.
- The purpose of this study was to investigate the applicability of different model of SHP and the method for getting its parameters to predict the actual evaporation under water-limited conditions.

2 Theory

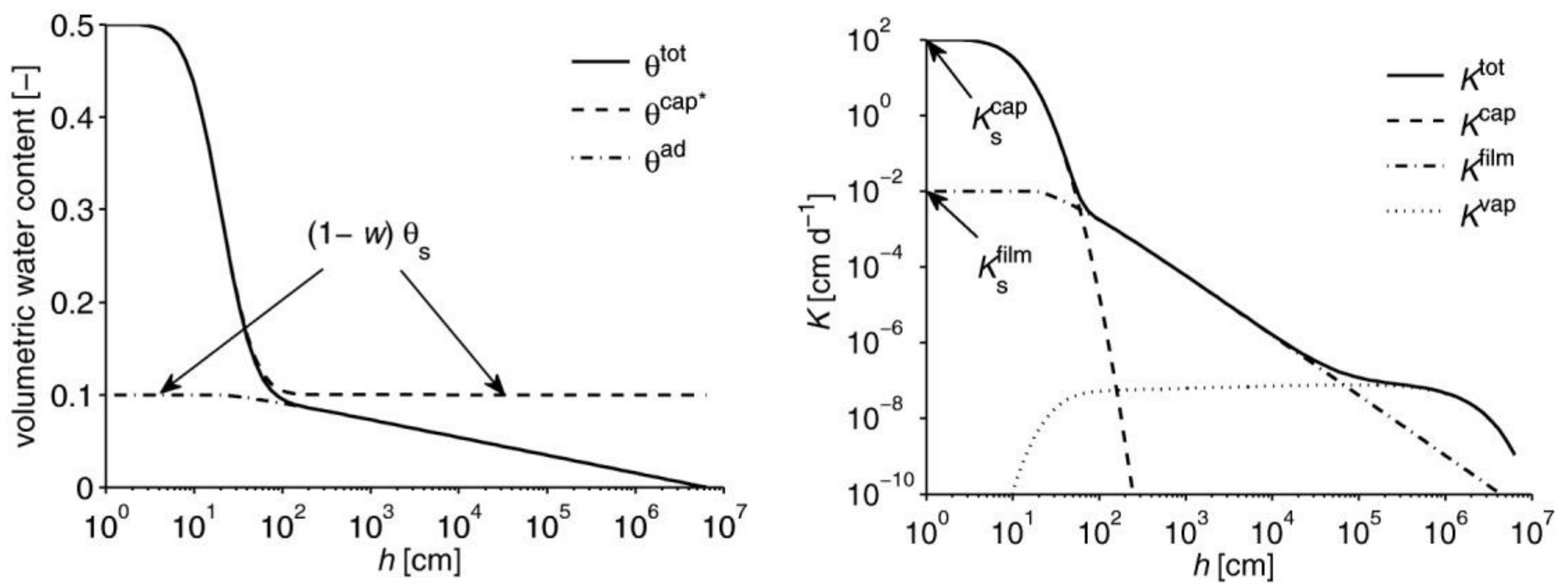


Figure 1: Inclusion of the non-capillary and adsorptive components to the water retention curve (left), and hydraulic conductivity curve (right). Image source: Peters (2013) WRR, 49(10).

3 Data collection

- Data was measured at the lysimeter station of the Research Institute for Post-Mining Landscapes (FIB) in Finsterwalde, Germany.
- A large bare field lysimeter (2.5 m height; 1 m^2 surface area) was exposed to the natural atmospheric conditions.
- Measured data in hourly time intervals, and for a 5 years period (2015-2019):
  - Lysimeter mass
  - Outflow mass
  - Pressure head and water content (FDR sensor)
  - Meteorological data

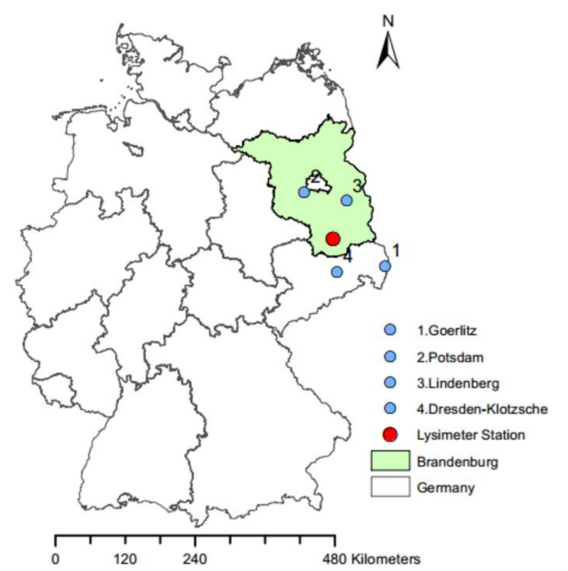
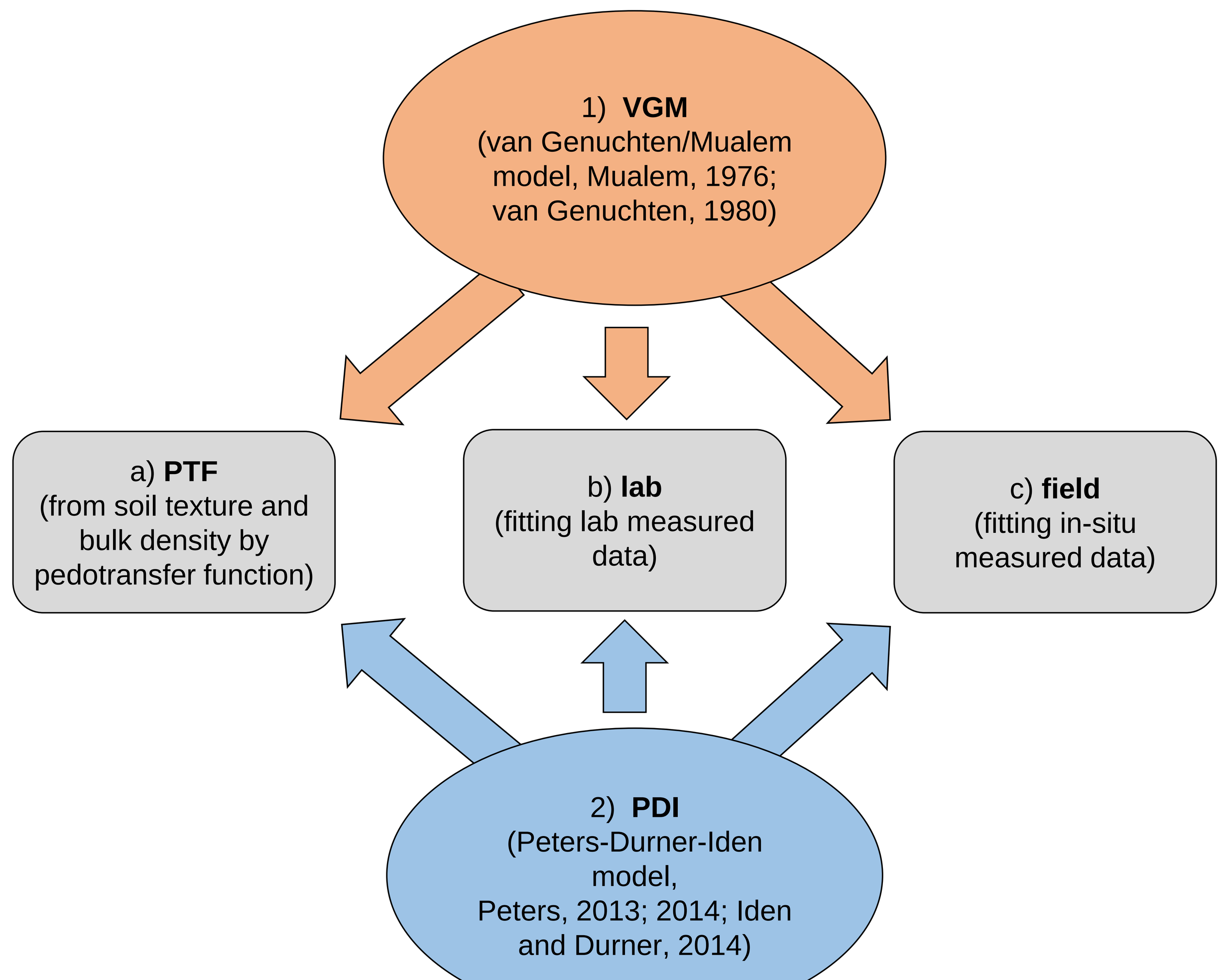


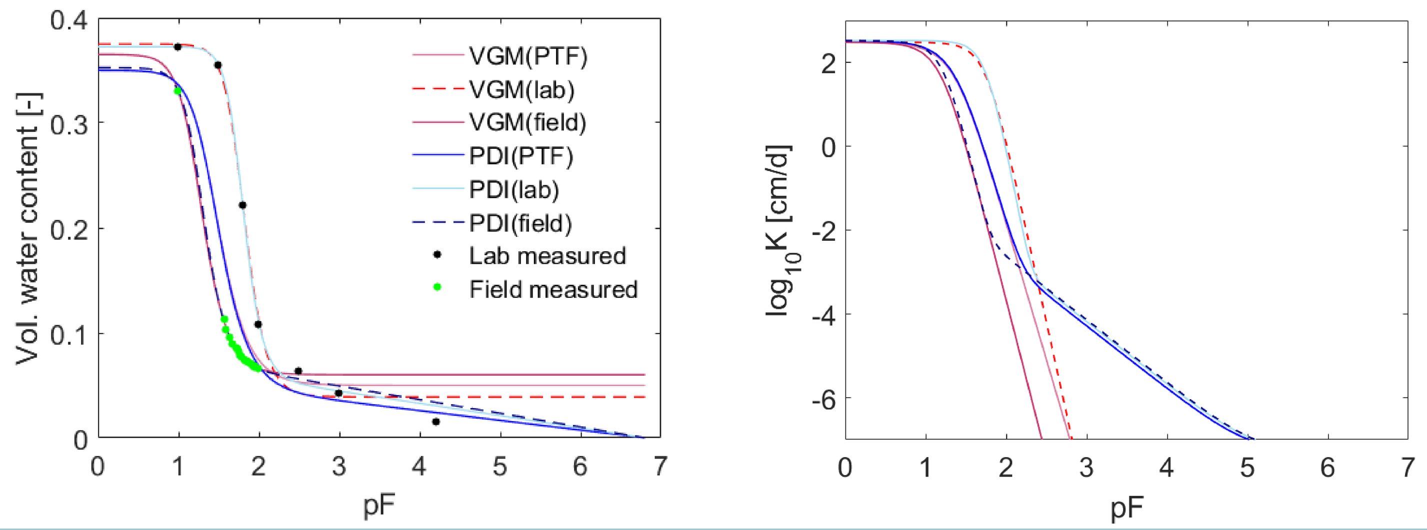
Figure 2: Location of the lysimeter measurement site and national German Weather Service stations.

4 Modelling



- Actual measured evaporation and rainfall were derived from changes in the mass of lysimeter using AWAT filter approach.
- Potential evapotranspiration, ET_p, was calculated using the FAO-56 version of the Penman-Monteith equation (Allen et al., 1998), based on meteorological data of 4 nearby weather stations.
- Potential bare soil evaporation, E_p, was obtained by scaling ET_p, by comparing measured evaporation (just after heavy rainfalls) with the calculated ET_p
  → $E_p/ET_p = 0.66$
- Modeling of the water dynamics in the lysimeters was performed using the HYDRUS 1-D software.
  - Boundary conditions: top: atmospheric conditions with E_P, bottom: seepage face
  - Initial condition: measured pressure heads profile (cm)

Figure 3: Soil hydraulic properties used for different modelling approaches.
Left: Water retention function,
Right: Hydraulic conductivity function.
Blue lines: PDI parametrizations.
Red lines: VGM parametrizations.



5a Results

Model/ Year	2015	2016	2017	2018	2019
Measured E	00.00	0.00	0.00	0.00	0.00
VGM (PTF)	-23.10	-27.39	-21.12	-28.60	-16.43
VGM (lab)	-22.75	-26.87	-20.10	-27.76	-15.32
VGM (field)	-33.80	-39.25	-34.23	-42.51	-31.98
PDI (PTF)	-3.71	-7.62	-2.04	-4.92	8.96
PDI (lab)	-6.58	-10.69	-5.88	-8.43	5.03
PDI (field)	-3.75	-8.44	-5.33	-4.96	7.70

Table 1: Relative differences of measured and simulated evaporation for different years. Values are shown in percentage.

5b Results

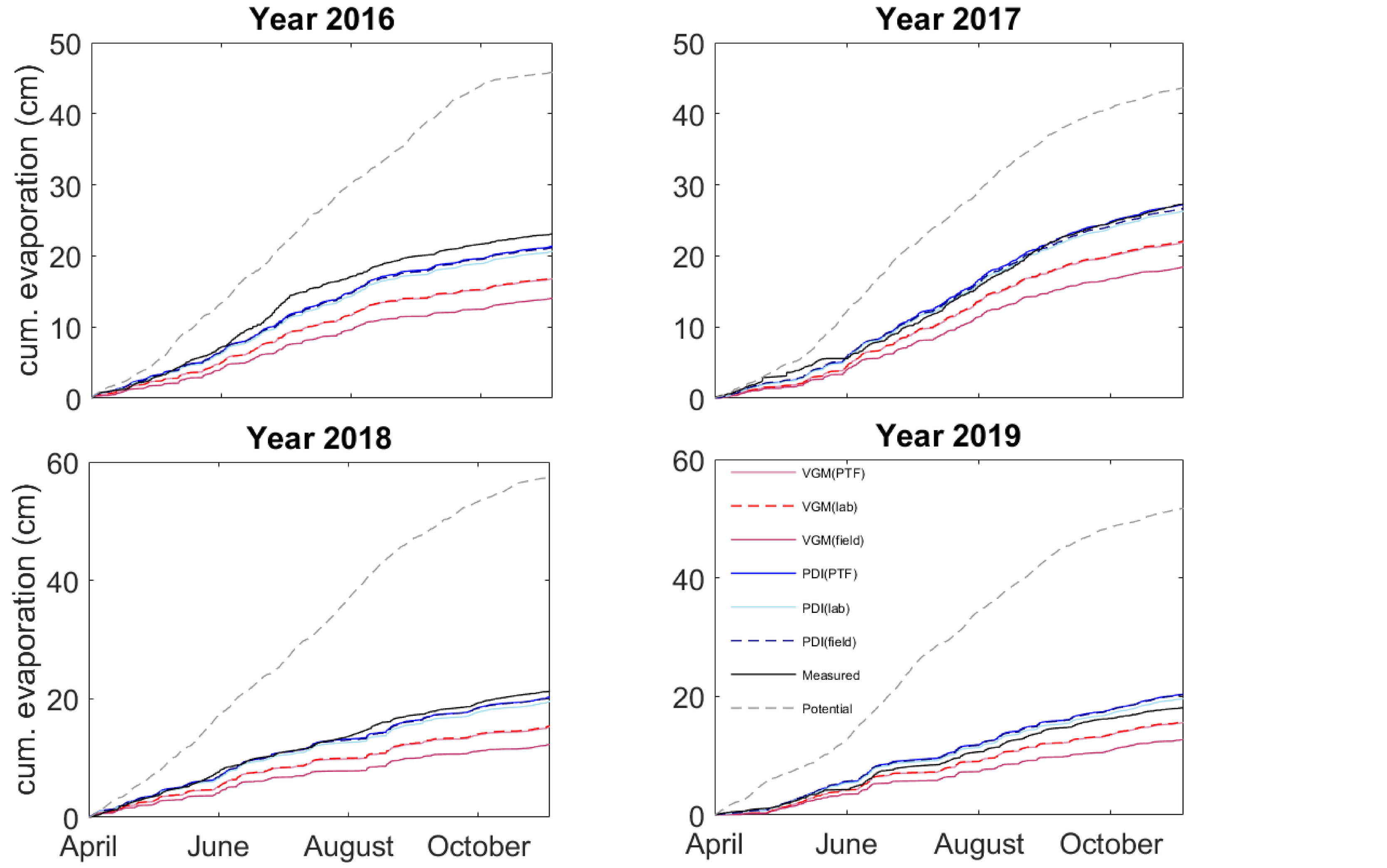


Figure 4: Measured and simulated cumulative evaporation (cm) for the VGM and PDI models during the summer season of years 2016-2019. Grey dashed line shows the potential bare soil evaporation.

- PDI predictions of Ea underestimated the observations by 5 % to 8 %, whereas using VGM models lead to an underestimation of 23 % to 35 %.
- Evaporation predicted with VGM models (red lines) was always less than predicted with PDI models (blue lines).
- For VGM, simulations based on field retention data always result in smaller E_a than those based on PTF and laboratory data.
- Evaporation predicted with PDI models also underestimated E_a in 2016 and 2018, matched well in 2017, and slightly overestimated E_a in 2019.
- Consideration of the non-capillary liquid water flow in the simulation significantly improves the prediction of evaporation.
- In present sudy, the source of data (PTF, lab, field) has less impact than the choice of model type.

References

VGM model: Mualem, Y. (1976), WRR, 12(3), 513-522: van Genuchten, M.T. (1980), SSSAJ, 44:892-898. The PDI model: Peters, A. (2013), WRR, 49(10), 6765-6780: Peters, A. (2014), WRR, 50(9), 7535-7539: Iden and Durner (2014), WRR, 50(9), 7530-7534. Predicted PDI conductivity curve: Peters, A. (2020), Poster at DBG-K1. AWAT filter: Peters et al., (2017), JH, 549, 731-740. Rosetta: Schaap, M. G., & Leij, F. J. (2000), SSSAJ, 64(3), 843-851.

Acknowledgement

The first author greatly acknowledges the support of the DAAD program. Experimental part of this research was conducted at the lysimeter station of Grünewalde, in Finsterwalde, Germany.