Universität Rostock

Traditio et Innovatio

Hydrologic evaluation of the curve number and Green and Ampt methods in a tile-drained catchment using SWAT

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Introduction

Artificial drainage can contribute significantly to nutrient pollution in surface waters of tile-drained catchments.

A realistic estimation of nutrient sources such as surface runoff, tileflow, and groundwater flow is essential in order to predict nutrient loads realistically.

SWAT provides two options for separating surface from subsurface flows, the empirical curve number and the physically based Green and Ampt method.

We evaluated both rainfall-runoff models for a small tile-drained agricultural catchment in northeastern Germany using observed data from 2004-2013 and applying the recently introduced Hooghoudt and Kirkham tile drain equations (Moriasi et al. 2012).

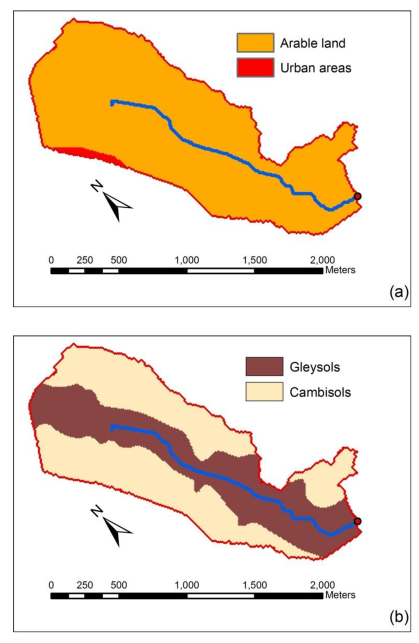
Research questions

1. Is the SWAT model capable of reasonably predicting discharge and tile flow using the Hooghoudt and Kirkham tile drain equations under the curve number and the Green and Ampt methods?
2. Does the choice of rainfall-runoff model substantially influence flow components?
3. To what extent do the tile drain parameters used impact discharge and flow component values?

Materials and Methods

Study area: - northeastern Germany near the city of Rostock
- 190 ha in total, 174 ha (92%) tile-drained
- land use: agriculture (winter wheat, winter barley, canola, corn)
- soils: Cambisols and Gleysols
- 700 mm mean annual rainfall, evenly distributed throughout the year
- 8 °C mean annual temperature with maxima in July (17.8 °C) and minima in January (0.3 °C)

Tile drainage specifications:
- tile size (RE.hru=50 mm)
- tile spacing (SDRAIN.hru=13.000 mm)
- depth of tiles (DDRAIN.mgt=1.100 mm)



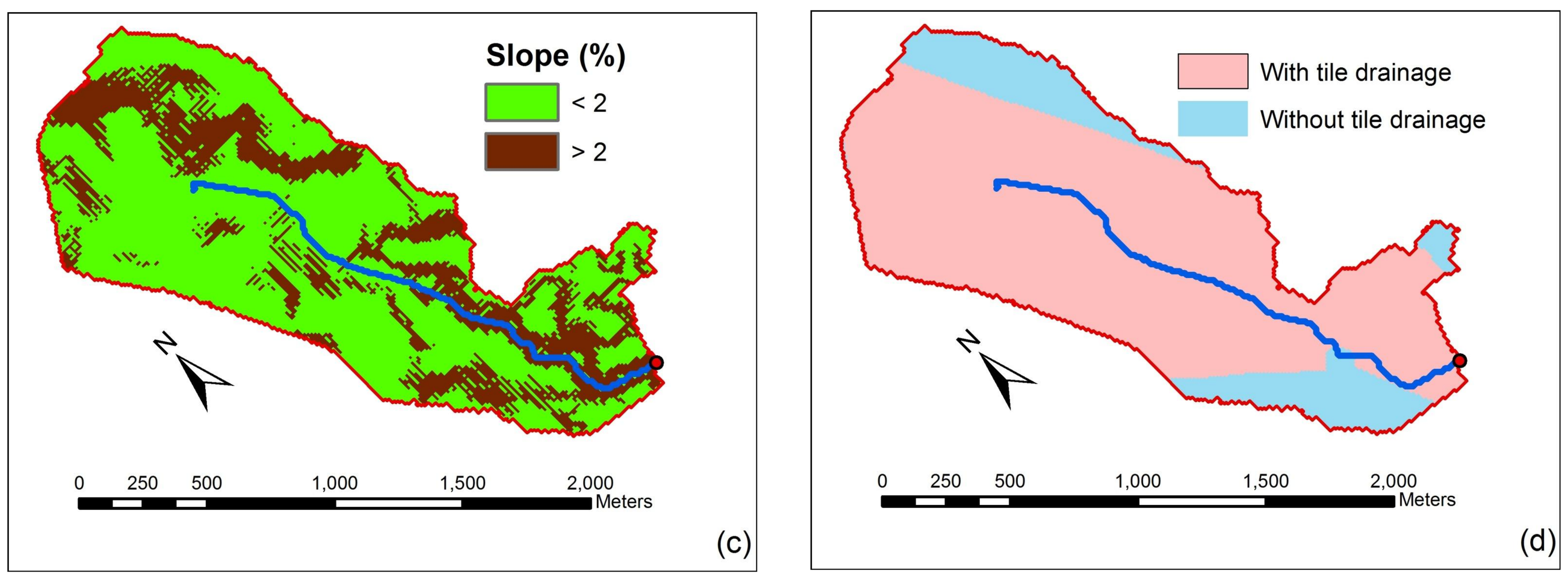


Figure 1: Study area with land use (a), soil types (b), slope conditions (c), and tile drainage (d).

Results

Model performance: streamflow

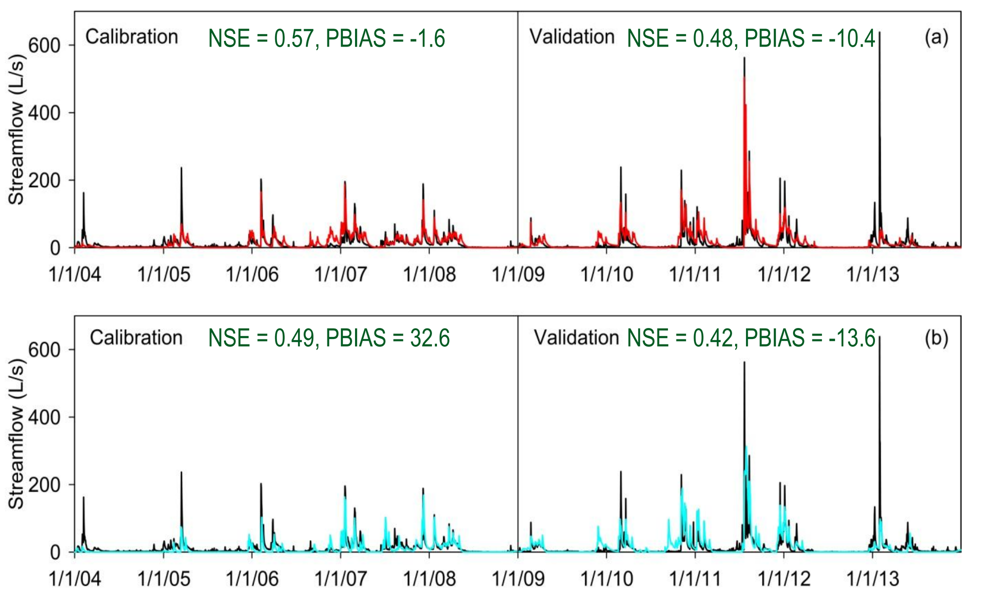


Figure 2: Observed (black lines) and simulated hydrographs comprising the calibration and validation period for the curve number (a) and Green and Ampt method (b).

Table 1: Calibrated parameters for the curve number and Green and Ampt method.

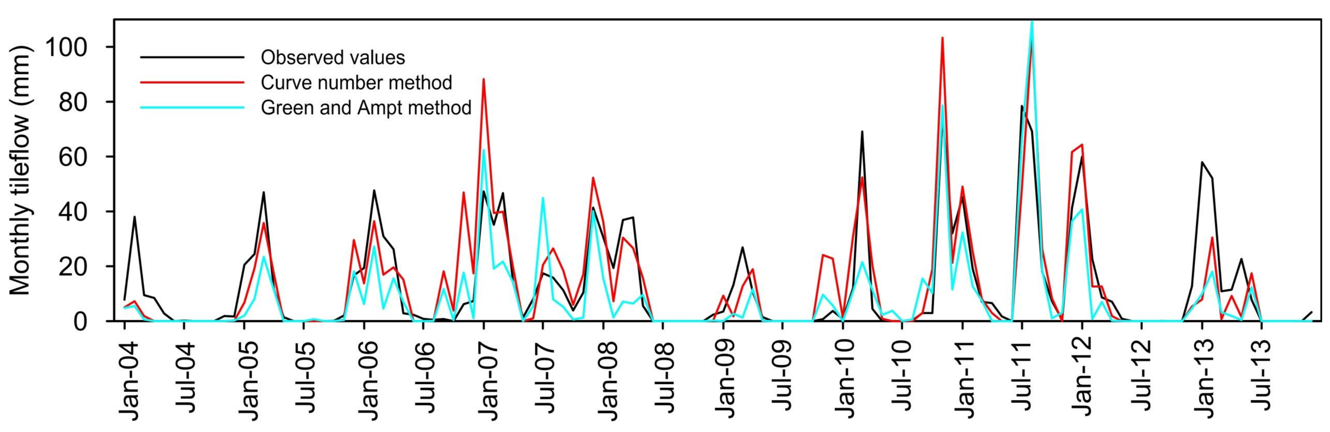
Parameter	Range	CN	G&A
CN2.mgt	35 to 98	55	54
DEP_IMP.hru(1)	0 to 6000	3650	4040
CANMX.hru	0 to 100	4.25	3.20
ESCO.hru	0 to 1	0.171	0.185
EPCO.hru	0 to 1	0.646	0.441
GWQMN.gw	0 to 5000	1711	1412
GW_DELAY.gw	0 to 500	14.4	0.5
ALPHA_BF.gw	0 to 1	0.10	0.90
CH_K2.rte	0 to 500	5	16
CH_N2.rte	0 to 0.3	0.09	0.02

Water balance and flow components

Table 2: Water balance for measured and simulated water balance components for the curve number and Green and Ampt method. All values are in mm. Percentage values are given in parentheses.

	observed	curve number	Green and Ampt
Precipitation	6990	6990	6990
Evapotranspiration		4455	4419
Discharge	2113 (100)	2258 (100)	1953 (100)
Surface runoff	n.a.	213 (9)	9 (0)
Lateral flow	n.a.	0 (0)	0 (0)
Tileflow	1558 (74)	1563 (69)	1002 (51)
Groundwater flow	n.a.	482 (21)	942 (48)

Model performance: tileflow



Calibration (2004 – 2008)
NSE_{daily} = 0.29 (CN), 0.38 (GA)
$NSE_{monthly}$ = 0.50 (CN), 0.40 (GA)
PBIAS = -3.2 (CN), 41.4 (GA)

Validation (2009 – 2013)
NSE_{daily} = 0.37 (CN), 0.30 (GA)
$NSE_{monthly}$ = 0.64 (CN), 0.62 (GA)
PBIAS = 2.4 (CN), 30.6 (GA)

Figure 3: Monthly observed and simulated tileflow for the curve number and Green and Ampt method from January 2004 until December 2013.

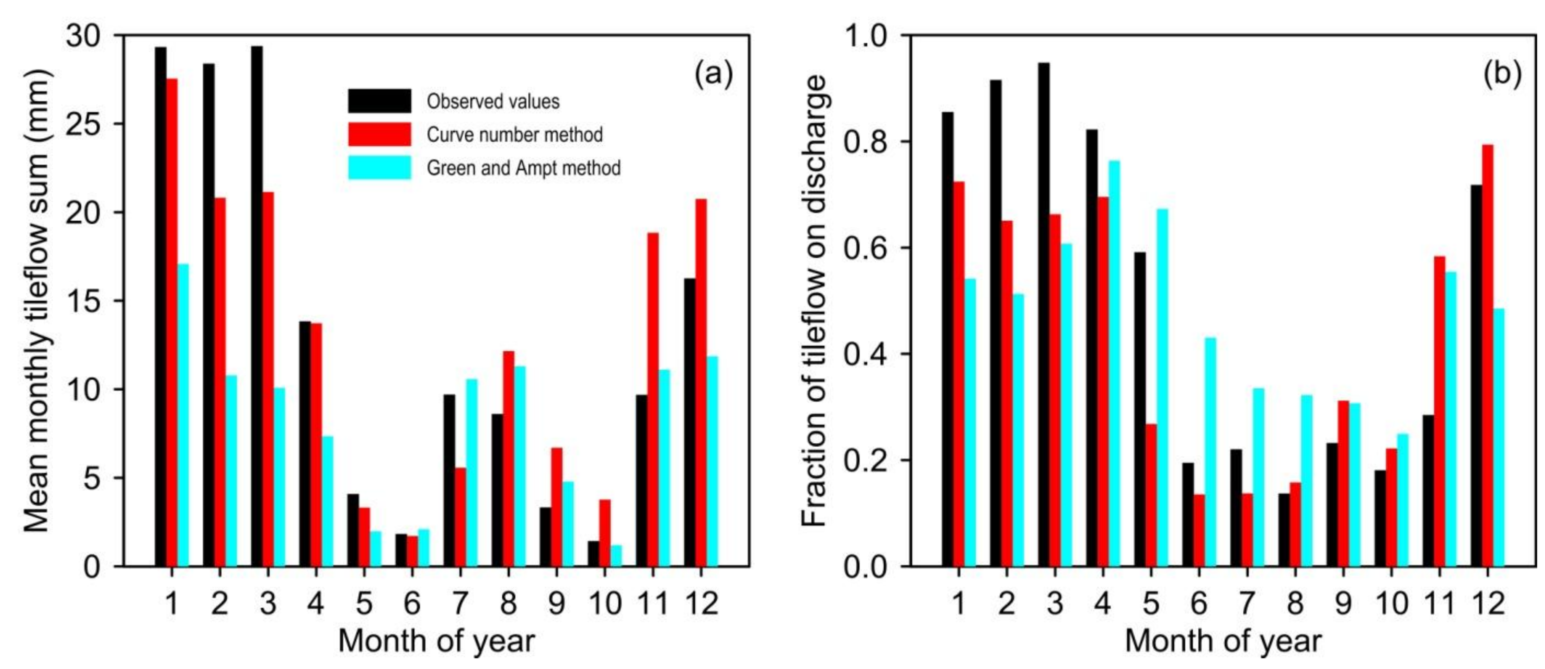


Figure 4: Mean monthly tileflow sums (a) and tileflow fractions (b) for the curve number and Green and Ampt method for the time period 2004-2013.

Reference
Moriasi, D.N., Rossi, C.G., Arnold, J.G., Tomer, M.D., 2012. Evaluating hydrology of the Soil and Water Assessment Tool (SWAT) with new tile drain equations. J. Soil Water Conserv. 67, 513–524.

Impact of tile-drain parameters

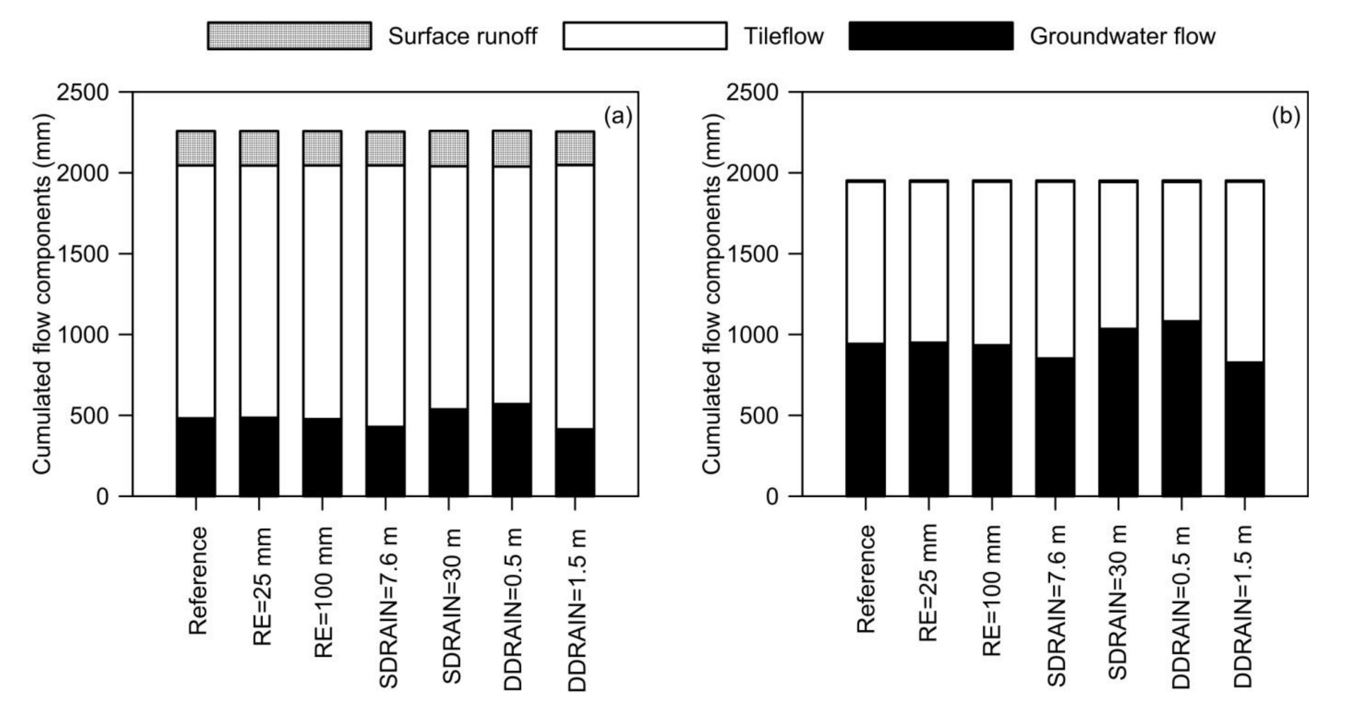


Figure 5: Flow components for different tile-drain parameter sets for the curve number (a) and the Green and Ampt (b) Method summed up for the time period 2004-2013.

Conclusions

Both the curve number and the Green and Ampt method reasonably predicted discharge (Figure 2) and tileflow (Figures 3, 4) using the new tile drainage algorithms under optimal parameter settings for each method (Table 1).

Model performances were always higher for the curve number method (Figures 2, 3).

The proportions of surface runoff, tileflow, and groundwater flow differed strongly between the two rainfall-runoff models (Table 2), with a more realistic estimation obtained using the curve number method (Table 2).

Different values for tile-drain radius, depth, and spacing did not affect discharge but tileflow (Figure 5).

Next step: Applying Green and Ampt method with varying rainfall intensities (ongoing Master thesis)

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