University of Nebraska - Lincoln

DigitalCommons@University of Nebraska - Lincoln

Agronomy & Horticulture -- Faculty Publications

Agronomy and Horticulture Department

2017

Supplemental Material for: Multi-site evaluation of APEX for water quality: II. Regional parameterization

Nathan O. Nelson

Claire Baffaut

John A. Lory

G.M.M.M. Anomaa Senaviratne

Ammar B. Bhandari

See next page for additional authors

Authors

Nathan O. Nelson, Claire Baffaut, John A. Lory, G.M.M.M. Anomaa Senaviratne, Ammar B. Bhandari, Ranjith P. Udawatta, Daniel W. Sweeney, Matt J. Helmers, Mike W. Van Liew, Antonio P. Mallarino, and Charles S. Wortmann

Supplemental Material for:

Multi-site evaluation of APEX for water quality: II. Regional parameterization

Nathan O. Nelson, Claire Baffaut, John A. Lory, G.M.M.M. Anomaa Senaviratne, Ammar B. Bhandari, Ranjith P. Udawatta, Daniel W. Sweeney, Matt J. Helmers, Mike W. Van Liew, Antonio P. Mallarino, and Charles S. Wortmann

Table of Contents *page*

List of Tables *page*

List of Figures *page*

S1. Explanation of Model Performance Evaluation Criteria

Model performance was assessed using Nash-Sutcliffe model efficiency (NSE), coefficient of determination (r^2), and percent bias (PBIAS) as defined by Moriasi et al. (2007 and 2015). Threshold values indicating acceptable model performance based on these statistics are dependent on the spatial and temporal scales of the data, water quality constituents of interest, and the modeling objectives (Moriasi et al., 2015). Although some standard values have been suggested (Moriasi et al., 2007 and 2015), considerable variability exist in the published literature. For instance Ramanarayan et al. (1997) considered r^2 >0.5 and NSE >0.40 as satisfactory for simulation of monthly surface water quality with the APEX model. Chung et al. (2002) defined r^2 > 0.5 and NSE > 0.3 as satisfactory for monthly tile flow and NO_3-N loss simulated with the Erosion Productivity Impact Calculator (EPIC) model. Wang et al. (2008) indicated r^2 > 0.5 and NSE > 0.4 as acceptable for monthly runoff and nutrient concentrations using the APEX model. Moriasi et al. (2007) suggested NSE > 0.5 with P-bias ±25% for streamflow, ±55% for sediment and ±70% for nitrogen and phosphorus for monthly values. They also indicated that NSE values can be relaxed for shorter time steps (daily events). Yin et al. (2009) reported NSE for event based runoff and sediment between 0.41-0.84 and r^2 between 0.55 - 0.85. Mudgal et al. (2010) regarded r^2 > 0.5 and NSE > 0.45 as threshold for satisfactory calibration and validation with event data.

Our current study was completed as a much smaller special scale and a relatively smaller temporal scale than the studies used to define the criteria listed by Moriasi et al. (2015), who suggested NSE > 0.5, 0.45, and 0.35 for runoff, sediment, and total P (TP) simulation. Furthermore, the objective of this study was to develop a regional model that could be used to estimate relative differences in long-term average annual P loss for different management practices. Because our calibration and validation time step was small (event-based, ranging from 1 to 3 days) but our time-scale of interest was very long (long-term average annual loss), we reduced the threshold for model performance evaluation criteria compared to that suggested by Moriasi et al. (2015). For the current study, the threshold values for acceptable model performance statistics for runoff were set at r^2>0.5, NSE>0.3 and |PBIAS|<35, <60, and <70 for runoff, sediment loss, and TP loss respectively.

Supplemental Table S1. Characteristics and data availability at field sites used for developing site-specific models and calibration and validation of the regional model.

Name and location	Site ID	Monitoring period	Management	Measurements[†]	Calibration events	Validation events	Relevant Publications
Knox County, Missouri, Greenley Research Center near Novelty, MO Three fields: 1.6 – 4.4 ha 41°01' N; 92°11' W	Knox	1993-1997	No-till corn-soybean cropping system with grass waterway, surface-applied P fertilizer prior to corn	Precip, Tmax, Tmin, Q, Sed, TP, TN, crop yields	47	94 (two datasets; 47 events each)	Udawatta et al. (2002) Udawatta et al. (2004)
Knox County, Missouri, Greenley Research Center near Novelty, MO Three fields: 1.6 – 4.4 ha 41°01' N; 92°11' W	KnoxB	1998-2010	No-till corn-soybean cropping system with grass and agroforestry contour buffers, grass waterway, surface-applied P fertilizer prior to corn	Precip, Tmax, Tmin, Q, Sed, TP, TN, crop yields	42	84 (two datasets; 42 events each)	Udawatta et al. (2011) Senaviratne et al. (2016b)
Chariton County, Missouri MRBI watersheds[‡] Two fields: 2.7 and 31.7 ha	Chariton	2011-2013	Corn-soybean cropping system, with and without winter cover crop and terraces	Precip., Q, Sed, TP, TN, crop yields	10	15	Senaviratne et al. (2016a)
Franklin County, Kansas Two terraced fields: 0.5 ha and 1.5 ha; 38°25' N, 95°7' W	Franklin	2001-2004	No-till soybean grain sorghum cropping system, surface applied fertilizer	Precip., Q, Sed, TP, DP, weather station 10 miles from site	36	34	Zeimen et al. (2006) Maski et al. (2008) Douglas-Mankin et al. (2010) Anand et al. (2007)
Crawford County, Kansas One 0.4 ha field; 37°30' N, 94°59' W	Crawford	2005-2008 2011-2013	Continuous grain sorghum cropping system, surface applied and incorporated N-based turkey litter	Precip., Q, Sed, TP, DP, weather station 20 miles from site	23	26	Zeimen et al. (2006) Sweeney et al. (2012)

[†] Precip = Precipitation, Tmax = Maximum daily temperature, Tmin = Minimum daily temperature, Q = Runoff, Sed = Sediment, TP = Total Phosphorus, TN = Total Nitrogen, DP = Dissolved Phosphorus
[‡] Location not given by agreement with landowner,

Supplemental Table S2. Control parameter values in site-specific calibrated models that were different from the best professional judgement parameterization, value selected for the regionally calibrated model (RCM) parameterization, and the method used to select the RCM value.

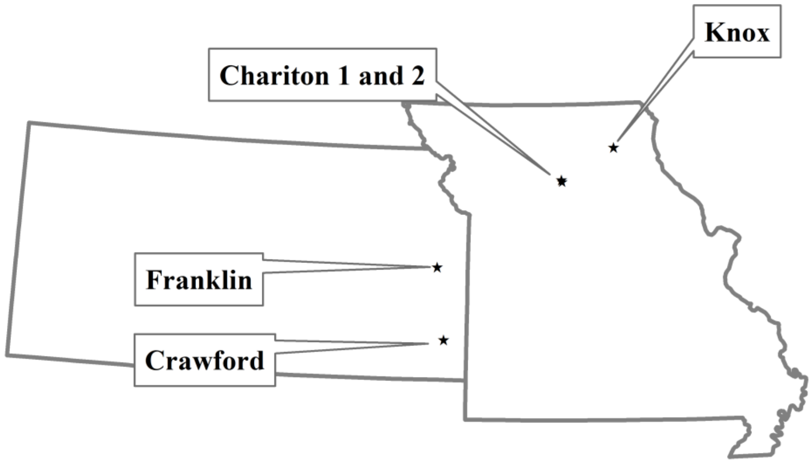
Parameter Name	Line, variable #	Definition	Knox	KnoxB	Chariton	Franklin	Crawford	RCM	Method of selection
NVCN	1, 15	Controls how the curve number (CN) is adjusted with soil moisture. Option 4 was "Variable daily CN SMI (soil moisture index)"	4	4	4	4	4	4	Most common value
ISW	2, 8	Selects the method for estimating the field capacity and wilting point. Option 0 was "Field capacity/wilting point estimated using the Rawls method (dynamic)" and option 3 was "Field capacity/wilting point inputted (static)."	0	3	0	0	0	0	Most common value
DRV	6, 1	Water erosion equation. Option 3 was "MUSS Small Watershed MUSLE."	3	3	3	3	3	3	Most common value

Supplemental Table S3. Site-specific calibrated model parameter values that were different from the best professional judgement parameterization, value selected for the regionally calibrated model (RCM), and the method used to select the RCM value.

Parameter	Definition	Knox	KnoxB	Chariton	Franklin	Crawford	RCM	Method for selection
3	Water stress-harvest index	0.5	0.5	0.3	0.5	0.5	0.5	Most common value
8	Soluble phosphorus runoff coefficient.	14	14	14	10	10	15	Regional calibration
15	Runoff CN residue adjustment parameter	0.02	0	0	0.02	0.02	0.02	Most common value
17	Soil evaporation – plant cover factor for regulating soil evaporation.	0.1	0.1	0.1	0.15	0.2	0.13	Average
19	Sediment routing coefficient	0.02	0.02	0.01	0.01	0.01	0.014	Average
29	Biological mixing efficiency	0.5	0.5	0.5	0.5	0.5	0.5	Regional calibration
31	Maximum depth for biological mixing	0.3	0.3	0.3	0.3	0.3	0.3	Regional calibration
42	SCS curve number index coefficient	2	1.5	2	2.5	2.5	2.3	Regional calibration
44	Upper Limit of CN retention parameter	2	1.5	1.5	2	2	1.7	Average
46	RUSLE C-factor coefficient in exponential residue function	0.6	0.9	0.7	0.85	1.2	0.65	Regional calibration
47	RUSLE C-factor coefficient in exponential crop height function	1	1	1	0.1	1.5	1	Knox and Chariton
59	Coefficient for upward P movement by evaporation	1	3	0.6	1	1	1	Most common value
62	Manure erosion equation coefficient	0.05	0.05	0.05	0.1	0.1	0.1	Crawford
68	Manure erosion exponent	1	1	0.5	1	1	1	Crawford
69	Coefficient adjusts microbial activity in the top soil layer	0.6	0.1	0.5	0.5	0.5	0.5	Regional calibration
70	Microbial decay rate coefficient	0.6	0.5	0.7	0.5	0.5	0.65	Regional calibration
71	Manure erosion coefficient based on above ground plant material	1.15	1.15	1.15	1.5	1.5	1.5	Crawford
76	Standing dead fall rate coefficient	0.001	0.0001	0.001	0.001	0.001	0.001	Most common value
84	Coefficient regulating P flux between labile and active pools	0.3	0.3	0.001	0.001	0.001	0.1	Regional calibration
85	Coefficient regulating P flux between active and stable pools	1	1	1	1	1	1	Recommendation by Baffaut et al. (2013)
90	Subsurface flow factor	2	2	2	10	10	2	Most common value
96	Soluble P leaching kd value	3	3	5	5	5	2	Regional calibration

Supplemental Table S4. Parameter values used for automated optimization with the PAROPT tool for the respective watershed models as part of the regional model development process (see Table S3 for parameter descriptions).

Parameter	Knox and KnoxB	Chariton	Franklin and Crawford
P8	10, 15, 20	10, 15, 20	10, 15 , 20
P29	0.3, 0.5	0.1, 0.3	0.3, 0.5
P31	0.15, 0.3	0.15, 0.3	0.15, 0.3
P42	2.0, 2.5	2.0, 2.5	2.0, 2.5
P46	0.75, 0.9	0.6, 0.75	0.6, 0.75
P69	0.5, 0.7, 1	0.5, 0.7, 1	0.5, 0.7, 1
P70	0.5, 0.6, 0.7	0.5, 0.6, 0.7	0.5, 0.6, 0.7
P84	0.05, 0.1, 0.3	0.05, 0.1, 0.3	0.05, 0.1, 0.3
P96	1,3, 6	1,3, 6	1,3, 6



Supplemental Figure S1. Location of the field sites used to calibrate site-specific models upon which the regional model was developed.

REFERENCES

Anand, S., K.R. Mankin, K.A. McVay, K.A. Janssen, P.L. Barnes, and G.M. Pierzynski. 2007. Calibration and validation of adapt and SWAT for field-scale runoff prediction. J. Am. Water Resour. Assoc. 43:899-910.

Chung, S.W., P.W.Gassman, R.Gu, and R.S.Kanwar. 2002. Evaluation of epic for assessing tile flow and nitrogen losses for alternative agricultural management systems. Trans. ASAE 45:1135.

Douglas-Mankin, K.R., D. Maski, K.A. Janssen, P. Tuppad, and G.M. Pierzynski. 2010. Modeling nutrient runoff yields from combined in-field crop management practices using SWAT. Trans. ASABE 53:1557-1568.

Maski, D., K.R. Mankin, K.A. Janssen, P. Tuppad, and G.M. Pierzynski. 2008. Modeling runoff and sediment yields from combined in-field crop practices using the soil and water assessment tool. J. Soil Water Conserv. 63:193-203.

Moriasi, D.N., M.W. Gitau, N. Pai, and P. Daggupati. 2015. Hydrologic and water quality models: Performance measures and evaluation criteria. Trans. ASABE 58:1763-1785.

Moriasi, D.N., J.G. Arnold, M.W. Van Liew, R.L. Bingner, R.D. Harmel, and T.L.Veith. 2007. Model evaluation guidelines for systematic quantification of accuracy in watershed simulations. Trans. ASABE 50:885-900.

Mudgal, A., C. Baffaut, S.H. Anderson, E.J. Sadler, and A.L. Thompson. 2010. APEX model assessment of variable landscapes on runoff and dissolved herbicides. Transactions of the ASABE 53:1047-1058.

Ramanarayanan, T.S., J.R. Williams, W.A. Dugas, L.M. Hauck, and A.M.S. McFarland. 1997. Using APEX to identify alternative practices for animal waste management. Part - I: Model description and validation. Paper - American Society of Agricultural Engineers 22 pp.-22 pp.

Senaviratne, G.M.M.M.A., C. Baffaut, J.A. Lory, R.P. Udawatta, N.O. Nelson, and A.B. Bhandari 2016a. Evaluation of four parameterization strategies for the APEX model. J. Environ. Qual. 45:(this issue).

Senaviratne, G.M.M.M.A., C. Baffaut, R.P. Udawatta, J.A. Lory, and S.H. Anderson. 2016b. Improved APEX model buffer simulations on water quality benefits at field-scale. J. Environ. Qual. 45:(this issue).

Sweeney, D.W., G.M. Pierzynski, and P.L. Barnes. 2012. Nutrient losses in field-scale surface runoff from claypan soil receiving turkey litter and fertilizer. Agric. Ecosyst. Environ. 150:19-26.

Udawatta, R.P., H.E. Garrett, and R. Kallenbach. 2011. Agroforestry buffers for nonpoint source pollution reductions from agricultural watersheds. J. Environ. Qual. 40:800-806.

Udawatta, R.P., J.J. Krstansky, G.S. Henderson, and H.E. Garrett. 2002. Agroforestry practices, runoff, and nutrient loss: A paired watershed comparison. J. Environ. Qual. 31:1214-1225.

Udawatta, R.P., P.P. Motavalli, and H.E. Garrett. 2004. Phosphorus loss and runoff characteristics in three adjacent agricultural watersheds with claypan soils. J. Environ. Qual. 33:1709-1719.

Wang, X., P.W. Gassman. J. R. Williams. S. Potter, and A.R. Kemanian. 2008. Modeling the impacts of soil management practices on runoff, sediment yield, maize productivity, and soil organic carbon using APEX. Soil & Tillage Research 101:78-88.

Yin, L., X. Wang, J. Pan, and P.W. Gassman. 2009. Evaluation of apex for daily runoff and sediment yield from three plots in the middle Huaihe river watershed, China. Transactions of the ASABE 52:1833-1845.

Zeimen, M.B., K.A. Janssen, D.W. Sweeney, G.M. Pierzynski, K.R. Mankin, D.L. Devlin, D.L. Regehr, M.R. Langemeier, and K.A. Mcvay. 2006. Combining management practices to reduce sediment, nutrients, and herbicides in runoff. J. Soil Water Conserv. 61:258-267.