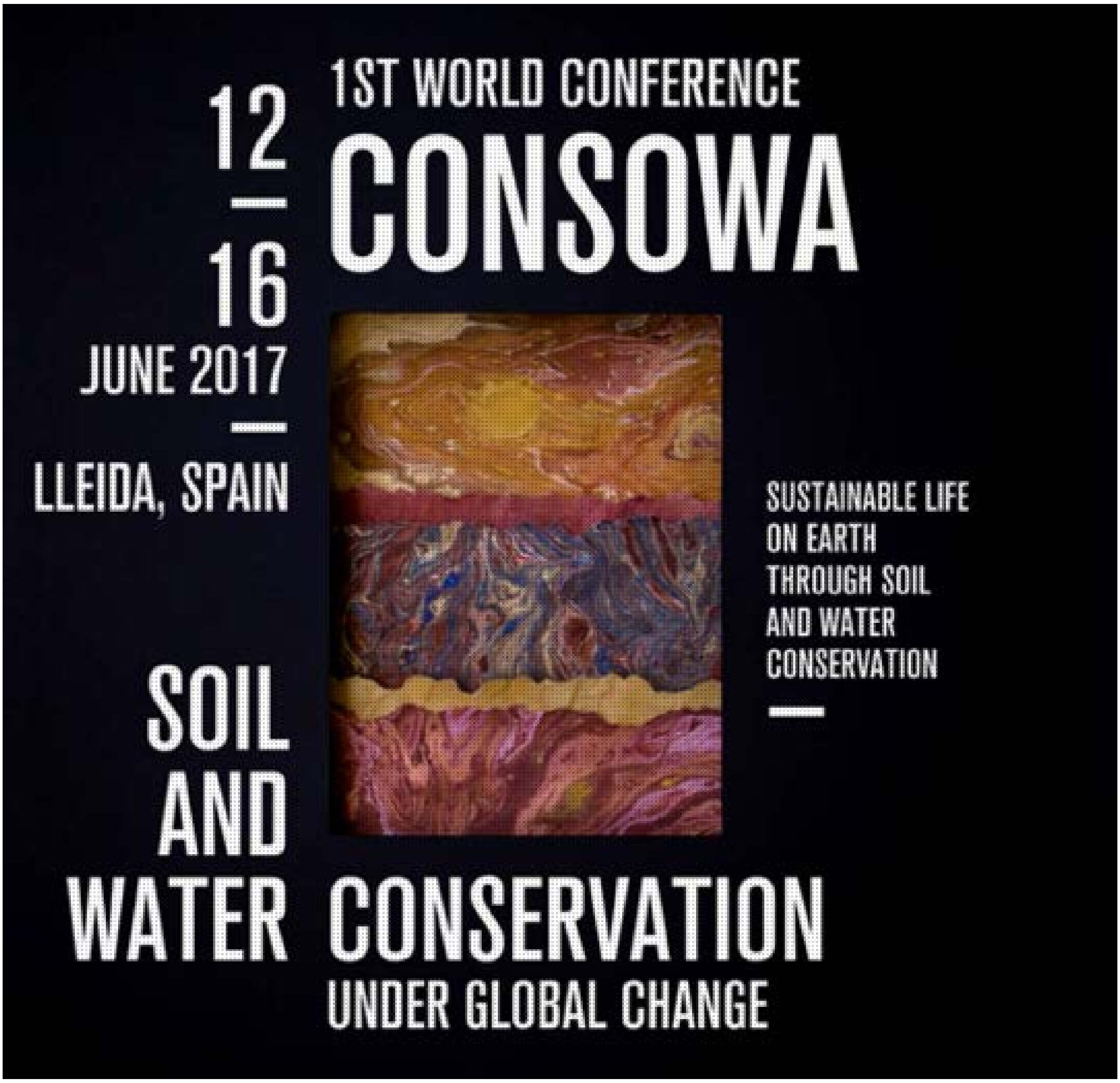

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USING A CONTINUOUS MODEL FOR REFINEMENT OF NUTRIENT RISK ASSESSMENT TOOLS

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INTRODUCTION

Implementation of nutrient management plans should protect the environment, maintain crop productivity, and increase profitability. Nutrient management planning is a complex process requiring planners knowing what resources are available and what needs are to be met. The Natural Resources Conservation Service (NRCS) 590 standard sets the national minimum standards for nutrient management in the U.S. (USDA-NRCS, 2012). The phosphorus (P) index (PI) is one of the management tools that can be used to identify agricultural fields with a high potential for runoff P losses. The PI is a systematic method for integrating a wide range of field characteristics into a prediction of the potential for P loss from the field. A revision of the 590 standard, suggested using the Agricultural Policy/Environmental eXtender (APEX) model as the new risk assessment tool to target critical source areas and practices to reduce agricultural non-point sources losses of sediments, P and nitrogen (N) (Sharpley et al., 2011).

APEX is a semi-process-based, distributed hydrologic and water quality model that operates at continuous daily time step (Radcliffe et al., 2015). This model has been used to evaluate various land management strategies considering sustainability, erosion (wind, sheet and channel), economics, water supply and quality, soil quality, plant competition, weather and pests (Steglich and Williams, 2013). However, APEX has been reported to have limitations due to model structure to accurately predict objective parameters (i.e. flow, sediments and nutrient losses) under different circumstances (e.g. Sen et al. (2012) and Collick et al. (2016)). Concerned that APEX could not adequately capture P losses, members of the USDA Southern Extension and Research Activity 17 (SERA-17) developed a white paper stating the need to compare Indices and water quality model performance, using edge-of-field based P runoff data (Sharpley et al., 2011).

In order to determine if APEX could be used to refine or replace P risk assessment tools in the southern region of the U.S., a study was performed to compare predictions from edge of field models, including

APEX, against measured P loss data to determine if models could be used for refinement or replacement of P Indices in the southern U.S.

METHODS

Uncalibrated and calibrated APEX model predictions were compared against measured water quality data from twenty different scenarios including row crops and pasture fields in four southern states of the United States. The general characteristics of the field sites can be found in Table 1. A detailed description of the water quality datasets used to evaluate the model can be found in Bolster et al. (2017) and Ramirez-Avila et al. (2017).

The information about soils, weather, agricultural operations (e.g. operation type and date, application rates) and soil properties in the fields (e.g. pH, soil test P) used to setup the model were supplied by researchers of the corresponding study sites and/or obtained from publications (Pierson et al., 2001; Yuan et al., 2013; Larsen et al., 2014; Edgell, 2015). The datasets for runoff depth and quality for the fields used to tests the model were directly supplied by the corresponding researchers.

Table 1. General characteristics of the sites

	Arkansas	Georgia	Mississippi	North Carolina
# Fields (Area)	Seven (0.4-ha)	Six (0.75-ha)	Two (11 & 13-ha)	Twenty (0.017-ha)
Annual Rainfall (mm)	1,215	1,000 - 1,120	990 - 1,300	1,020 - 1,195
Crop	Fescue (Hay-and-Grazing)	Bermuda grass/Fescue	Soybean/winter wheat Cotton/winter wheat	Sweet corn/winter wheat
Soils	silt loam	fine sandy loam & sandy loam	silty clay loam, loam, very fine sandy loam & clay	silt loam
Slope (%)	2.0	6.0 to 8.0	0 to 6.5	3.5 to 4.3
Mehlich-3 P (mg-P kg^{-1})	91 – 183	22 to 53	38 and 50	27 to 81
Field and nutrient management	Hay No-P Hay org.-P (broadc.) Hay org.-P (injected) Cont. grazing org.-P Rotat. grazing org.-P	Organic-P	Red. Tillage inorganic-P	Conv. Till. Inorg.-P Conv.Till. org.-P No Till. Inorg.-P No Till org.-P
Applied P rate (kg ha^{-1})	0 to 80	215 to 327	9.5	0 to 114

Model performance for event-based runoff, sediment and P loads predictions was evaluated using the Nash-Sutcliffe efficiency (NSE) and percent bias (PBIAS) with critical values of NSE ≥ 0.30 and absolute value of PBIAS < 0.35, 0.6, 0.7, and 0.7 for runoff, sediment, dissolved P (DP) and total P (TP), respectively. Comparisons were made on an event basis.

RESULTS

Overall, uncalibrated and calibrated APEX models predicted runoff depths that met the performance criteria for the event-based predictions for Georgia, North Carolina, and Mississippi (Table 2). Runoff depths were highly overestimated in Arkansas as the weather time series used to setup the model affected its performance. Overall, neither the uncalibrated nor the calibrated model could accurately predict sediment, DP, or TP losses. Satisfactory performance for calibration of sediment loss was observed only from predictions on the Mississippi fields. TP loads in Arkansas met the performance criteria. However, since the runoff and sediment predictions were unsuccessful, the P predictions at this site are questionable. APEX is not sensitive to predict small concentrations and loads of nutrients (Francesoni et al., 2014), which could cause inaccurate predictions of TP and DP loads at the evaluated sites. Unsuccessful performance and underestimations in surface applied organic P sites could be caused because APEX lacks a routine for predicting manure-P processes on the soil surface. APEX also overestimated the P loss carried by irrigation-runoff events in Mississippi, caused by the overestimation in sediment loss from irrigation-runoff events.

Table 2. APEX model performance estimates for uncalibrated and calibrated predictions in Arkansas, Georgia, North Carolina and Mississippi.

	Uncalibrated				Calibrated			
	AR	GA	NC	MS	AR	GA	NC	MS
Runoff								
NSE	-17.08	0.58	0.21	0.67	-0.10	0.70	0.47	0.72
PBIAS (%)	-12.15	17.08	-3.42	47.22	-5.38	2.59	-2.50	19.65
Sediment								
NSE	-321534	-	-160	0.34	-0.28	-	0.02	0.48
PBIAS (%)	-13057.9	-	-752	49.77	30.65	-	47.55	21.74
Total P								
NSE	-118.27	-0.10	-0.34	-0.51	-0.34	-0.34	-0.27	-0.79
PBIAS (%)	-296.65	-11.10	78.05	74.17	77.43	86.37	86.21	53.8
Dissolved P								
NSE	-1.39	0.04	-0.05	-0.61	-0.46	-0.27	-0.15	-1.79
PBIAS (%)	46.62	5.39	84.27	89.04	77.06	91.36	95.96	6.79

CONCLUSIONS

Based on the analysis of key details about the observational data and model characteristics, it was concluded that the capability of APEX to predict P losses is limited and consequently, cannot be used to refine or replace P indices in the southern U.S. Results identified a critical need for reviewing and updating APEX routines to better represent the effects of the nutrient management factors immersed on the PI that influence potential P movement to surface waters.

More detailed and extended analysis for the study is presented in Ramirez-Avila et al. (2017)

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