



SWAT 2015

INTERNATIONAL SOIL & WATER ASSESSMENT TOOL CONFERENCE

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Book of Abstracts



The Soil and Water Assessment Tool (SWAT) is a public domain model jointly developed by USDA Agricultural Research Service (USDA-ARS) and Texas A&M AgriLife Research, part of The Texas A&M University System.

SWAT is a small watershed to river basin-scale model to simulate the quality and quantity of surface and ground water and predict the environmental impact of land use, land management practices, and climate change. SWAT is widely used in assessing soil erosion prevention and control, non-point source pollution control and regional management in watersheds.

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Foreword

This year the Soil and Water Assessment Tool (SWAT) model reaches 25 years of continued development. Over the years, SWAT has reached a vast number of water professionals and graduate students around the world to provide a platform to test their hypotheses and continue to push their research to solve global water resources problems.

The organizers of the 2015 International SWAT Conference at Purdue University want to express their thanks to Purdue University along with Bernie Engel, Indrajeet Chaubey, Jane Frankenberger, and Venkatesh Merwade for their countless hours and efforts to host the SWAT Community. In addition, we would like to thank our conference coordinator, Shannon Borneman with Purdue Conferences, for her work setting up registration, food, and logistics for the conference. On behalf of the SWAT Community, we extend our sincere gratitude to you and your university for the kind invitation and welcoming hospitality.

We would also like to thank the scientific committee for their support in preparing the conference agenda and allowing for scientists and researchers around the globe to participate and exchange their scientific knowledge at this conference.

This conference marks our silver jubilee celebration of the SWAT model's first 25 years. SWAT developers would like to thank all those who have contributed to SWAT development over the years, allowing SWAT to become a successful model with well over 2300 peer-reviewed publications. The developers hope to continue our work together for another 25 years of continued success. We are happy to be celebrating 25 years at the place where it all started—Purdue University. Go Boilers!

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SWAT+: Introduction to the new SWAT code, input/output file structure, test datasets and developers' interface

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Abstract

Since the release of the first version of the Soil and Water Assessment Tool (SWAT) two decades ago, several new variables and subroutines have been integrated in the model, making it more difficult to manipulate and maintain. Therefore, the SWAT code and the input and output file structure are currently being completely revised. SWAT+, the new version of SWAT, simplifies the maintenance of the code, the integration of new variables and the sharing of data. In addition, it gives the user more flexibility in defining the spatial interactions within a watershed, since hydrologic response units, subbasins, aquifers, reservoirs and reaches are treated as separate spatial objects. Thereby, it also facilitates the implementation of landscape units to improve the spatial representation of hydrological processes in the watershed.

Currently, three watersheds in the United States are used to test and debug SWAT+: the Little River Experimental Watershed in Georgia, the Middle Bosque River Watershed in Texas and the South Fork Wildcat Creek Watershed in Indiana.

This session is intended to give interested SWAT users an overview of

- the new modular SWAT code and input file structure,
- the increased flexibility in terms of spatial interactions within the watershed,
- the datasets used to test and debug the new codes and input files,
- the integration of landscape units in the model and
- the developers' interface that is currently used to set up and edit SWAT+ models.

The last part of the session will be reserved for user questions and suggestions.

Assessing projected climate impacts on streamflow in small coastal basins of the Western United States

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Abstract

The impacts of climate change on watershed hydrology, particularly streamflow quantity and timing, are becoming increasingly important to current and future management of our water resources. Western U.S. coastal watersheds have displayed a different response to climate change over the past 50 years as compared to mountainous watersheds. Coastal watersheds have had later streamflow timing as opposed to the earlier streamflow timing observed in mountainous watersheds. Despite the dissimilarity of coastal and mountainous watersheds, there is a lack of hydrologic modeling in these coastal watersheds. Through the use of the Soil and Water Assessment Tool (SWAT) coupled with downscaled General Circulation Model (GCM) data, it is possible to assess and project future hydrology at the watershed and subwatershed scales through the 21st century. This work focuses on five sites along the West Coast of the U.S., each with its own calibrated SWAT model. This presentation will look at the findings of this assessment at each site along the West Coast of the U.S., utilizing 21 and 19 GCMs each from Representative Concentration Pathways (RCPs) 8.5 (high emissions) and 4.5 (low emissions) respectively. There will be a focus on changes in interannual streamflow quantity, timing, distribution, and variability, comparing historic streamflow trends to those of the mid- and late-21st century. Additionally, the relative influence of temperature and precipitation on streamflow at each site will be analyzed and discussed. Lastly, long-term trends across the West Coast, and at each site specifically will be assessed.

Keywords

hydrology, modeling, climate change, coastal, SWAT

Climate change impact assessment on long term water budget for Maitland catchment in southern Ontario

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Abstract

Changing climate has become a matter of grave concern for the past few decades and scientific community is making all efforts to make a reasonable assessment on its impact on long term water budget at various parts of the globe. In the present study SWAT model is employed in order to assess the basin yield of a southern Ontario catchment. Climate projections are then forced into the model in order to access the variation in the basin yield in terms of surface and ground water.

Maitland River, a west flowing perennial stream, draining through southwestern Ontario and discharging into Lake Huron is having total catchment area of 2455 km². The basin is predominantly an agricultural land with more than 82% of the area occupied under cultivation. The SWAT model dataset was developed based on the soil details obtained through Soil Landscapes of Canada (SLC), land use data from Southern Ontario Landuse Information System (SOLRIS), weather data from the Environment Canada climate stations located within and in vicinity of the catchment. The model is calibrated and validated using the 12 years of recorded flows at three stream gauging locations within the catchment. Calibration and validation was carried out based on Nash-Sutcliffe efficiency and r^2 parameter. Both the test statistics were found close to 0.8 for annual and monthly water budgets.

The hydrological response of the Maitland catchment under the future projected climate scenario following the Representative Concentrated Pathways (RCP) 4.5 is also studied. The outputs of CanRCM4 model under CMIP5 experiment were forced into the hydrological model. The results of impact of the future climate on water yield are further discussed in the presentation.

Keywords

Maitland River, climate change, CanRCM4

Climate and Land Use/Cover Change Impacts on the Ecologically Relevant Flow Metrics in the Cahaba River

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Abstract

The Cahaba River is identified as the longest free flowing river in the State of Alabama, and The Nature Conservancy noted it as one of the only eight “Hotspot of Biodiversity” out of 2,111 watersheds in the contiguous United States. This study explored the impacts of land use/cover (LULC) and climate changes on hydrological responses in rapidly urbanizing upper Cahaba River basin in north-central Alabama, in particular the effect on low-flow regimes. Past, present and future potential streamflow responses to climate change are analyzed based on ecologically relevant flow metrics. We used 32 key flow metrics that captures low, high, median flow as well as flashiness, which are known to have significant impacts on the flora and fauna. These flow metrics, thus the ecology, will certainly be affected by LULC and climate change. Daily streamflow was produced from 1948 to 2015 using historical climate and LULC data with SWAT. Future daily streamflow was generated using CMIP5 climate data up to year 2098 with eleven climate models under four different emissions scenarios. The 150 year period from 1948 to 2098 was partitioned into five intervals, each 30 years in length. The daily streamflow from each period was fed into the Indicators of Hydrological Alterations (IHA) software to calculate the 32 flow metrics in each period. Differences in the flow metrics were assessed, which may hint for increase/decrease in native species’ density that may have occurred in the past or might occur in the future.

Keywords

Climate change, Land use/cover change, Urbanization, SWAT, CMIP5, Flow regime alterations.

Development of a SWAT-based methodology to evaluate, at municipal scale, the vulnerability of the agricultural sector to climate change

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Abstract

In México, climate change will negatively affect the productivity of the agricultural sector, putting food security at risk. The vulnerability of the agricultural sector is a useful tool for designing plans for adaptation to climate change; and according to the IPCC, it is a function of the adaptive capacity and the magnitude of the impact. The aim was to develop a methodology to assess and map, at the municipal scale, the vulnerability of the agricultural sector to climate change. The methodology was developed with data from 624 municipalities grouped in eight basins located in the tropical southeastern Mexico. For each municipality and basin, they were carried out the following activities: 1) Detailed characterization of the agricultural sector including 12 crops. 2) Development of a synthetic index to evaluate the adaptive capacity (ICA); which was made up of five sub-indices: availability and quality of natural resources (NR) level of human (HD), economic (ED), technology (TD) and infrastructure (ID) development. 3) Development of an index to assess the magnitude of the impact on crop productivity (IIP); which was evaluated for 12 crops using the SWAT model, under the IPCC greenhouse gases emission scenario A1B, during the years 2012 (baseline), 2030, 2060 and 2090. 4) Development of a municipal vulnerability index to climate change (IVM); which is calculated through a double entry matrix, considering three categories of ICA and IIP. The IVM for each municipality was classified as: extremely vulnerable, very vulnerable, vulnerable, low vulnerable and not vulnerable. Results indicate that from the 624 municipalities; 255, 350 and 19 have low, medium and high ICA, respectively. Regarding the magnitude of the impact on productivity; 284, 51 and 289 municipalities showed a high, medium and low IIP, respectively. As for the IVM; 26 municipalities are extremely vulnerable, 264 are very vulnerable, 248 are vulnerable, 85 are few vulnerable and only 1 is not vulnerable. It is concluded that the methodology developed and its associated databases, may be the basis to support decision-making and design at the municipal scale and basin, plans for the adaptation of the agricultural sector to climate change.

Keywords

Vulnerability, crop grow simulation, adaptive capacity, climate change

Analysis of Watershed Soundness by Water Balance and Water Quality Variation Using SWAT Model for Han River Basin, South Korea

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Abstract

Water balance and water quality for watershed soundness assessment was investigated for Han River basin (34,148 km²) of South Korea using a watershed-scale hydrologic model, SWAT (Soil and Water Assessment Tool). To predict the reliable available water quantity of the basin, the model was established by dividing the basin into 237 subbasins as standard watersheds and the water resource facilities of 4 multipurpose water supply dams and 3 multi-function weirs were considered. The SWAT was spatially calibrated (2005-2009) and validated (2010-2014) using daily observed dam and weir inflows, evapotranspiration, soil moisture and water quality data. The SWAT simulated the present water balance considering the surface-groundwater interactions and water quality variation and quantified the basin scale relationship of hydrologic cycle and water quality. Simulation results indicated the spatial and temporal variability of water balance conditions by evaluating the hydrologic components of infiltration, evapotranspiration, streamflow, percolation, soil moisture, baseflow, and groundwater recharge and Influences of water quality change on water balance conditions. Finally, we assessed the watershed soundness and vulnerability of water resources and water quality for executable watershed management.

Acknowledgement

This research was supported by a grant (14AWMP-B079364-01) from Water Management Research Program funded by Ministry of Land, Infrastructure and Transport of Korean government.

Keywords

SWAT, Dam operation, Water balance, Water quality, Watershed soundness

Streamflow Generation Responses to Extreme Hydrometeorological and Climate Events in an Intensively Agricultural Watershed

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Abstract

Hydrological models able to reproduce hydrologic regimes in response to extreme hydrometeorological and climate events (EHCE) are relevant for watershed management. Our goal is to characterize the sensitivity of streamflow generation to EHCE in a heavily agricultural watershed. The Shell Creek (SC) watershed (1,244 km²) is located in east-central Nebraska with a large portion of the land in cultivated crops (78.2%), and a significant number of cattle and swine animal feeding operations. The objective of this study is to simulate streamflows in SWAT and evaluate changes in response to EHCE in SC. We hypothesized that short-intense precipitation events generates greater discharges than long-moderate rainfall after dry periods. Intensive land-uses modify natural cover and first soil layers, which reduce water infiltration rates while let to a quick rainfall-runoff response. To test that hypothesis we use SWAT and results were processed statistically. We forced the model with weather variables (i.e. precipitation and minimum and maximum temperatures,) for a timespan of 60 years. Calibration of the model was performed in SWAT-CUP. Two parameters were calibrated. The initial SCS runoff curve number for moisture condition II (CN2), and the Manning's *n* for main channel (Ch_N2). The Generalized Likelihood Uncertainty Estimation (GLUE) procedure was used to evaluate the model performance, and the likelihood was measured by the Nash-Sutcliffe Efficiency (NSE). The model was successfully calibrated with a NSE of 0.55. The CN2 and Ch_N2 values that better fit the model were 83.1 and 0.036, respectively. Percentiles of streamflow were obtained through the use of Gama distribution function on the simulated streamflows. Percentiles of streamflow were used as indices of EHCE to characterize and identify droughts (below 30th percentiles) and floods (percentiles above 70th percentile and soil moistures above similar percentiles). Streamflows generated in response to such events were contrasted with averaged streamflows from historical simulations produced during the same timespan. Future directions will consider validation of the calibrated model, and ultimately modeling water quality, especially emergent contaminants in SC.

Keywords

SWAT; extreme precipitation events; runoff generation; agricultural land-use; Shell Creek

Daily streamflow prediction in ungauged watersheds with a hybrid model: SWAT-ANN

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Abstract

A hybrid ANN-SWAT model was developed to predict daily streamflow in ungauged watersheds. In this approach streamflow is first simulated using the SWAT model with the default model parameters, i.e. no model calibration is involved. The SWAT simulated baseflow and direct runoff are then used as inputs to ANN. Daily streamflow data from 29 USGS stations in and around the metropolitan Atlanta area were used to test this approach and the predictive models were built with *leave-one-site-out jackknifing* technique (i.e. at each step 28 site is used for training and one is used for testing). Comparison of results from this hybrid approach to SWAT showed better performance in general. It was concluded that coupling of machine learning-based techniques with watershed models can improve the daily flow prediction and the modeling efficacy. This approach has the added benefit of eliminating the need for sensitivity analysis and calibration of the SWAT model. However, this approach is only applicable when there is sufficient number of streamflow data from nearby watersheds.

Keywords

ANN, ungauged watershed, daily flow

Spatial and temporal evaluation of hydrological response to climate and land use change in South Dakota watersheds

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Abstract

This study explored hydro-climatological changes between two recent decades (1980s and 2000s) with the Soil and Water Assessment Tool (SWAT) in three representative watersheds in South Dakota. The Bad River Watershed (BRW) in the west, and Skunk Creek Watershed (SCW) and Upper Big Sioux River Watershed (UBSRW) in the east. Two SWAT models were created from 1981 to 1990 and from 2005 to 2014 for each watershed with land cover maps of 1992 and 2011 from the National Land Cover Database (NLCD), corresponding respectively to 1980s and 2000s, to represent land use change and characterize hydrological changes between the two time periods. The models were calibrated for daily streamflow for at least five years (R^2 and NSE > 0.39; PBIAS = $[\pm 24]$) and validated for at least four years (R^2 and NSE > 0.37; PBIAS = $[\pm 47]$). Simulation results showed that surface runoff, soil water content, water yield and percolation increased by more than 7 mm, 18 mm, 7 mm and 3 mm, respectively, in all three watersheds. Evapotranspiration (ET) increased by more than 10 mm in BRW and UBSRW; but decreased by 49 mm in SCW. Between 1980s and 2000s, seasonal variation in hydrology mostly increased during the wet season (i.e May to October) in all three watersheds. Spatial analysis revealed that the hydrological components increased with a decrease in grassland in the watersheds, except in SCW where ET decreased between the two time periods. Overall, hydrological changes occurred between 1990s and 2000s in the study watersheds.

Keywords

Hydrology, SWAT, South Dakota

Assessing the influence of climate variability on land use change from cotton to perennial bioenergy grasses: implications on watershed hydrology and water quality

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Abstract

The semi-arid Texas High Plains (THP) region, which is dominated by cotton cultivation, has the potential to grow perennial bioenergy grasses of Alamo switchgrass (*Panicum virgatum* L.) and *Miscanthus × giganteus*. This region is characterized by high temperatures and low precipitation and it has experienced recurring droughts in the recent times. Assessing the impacts of hypothetical land use change from cotton to perennial grasses on hydrology and water quality, and studying the influence of climate variability on proposed land use change is critical for making better decisions on land use and adoption of the best management practices in this intensive agricultural region. In this study, the Soil and Water Assessment Tool (SWAT) was used to simulate the long-term (1994-2009) effects of proposed land use change on biofuel production potential, watershed hydrology and water quality in the Double Mountain Fork Brazos watershed of the THP. In addition, a climate variability/sensitivity analysis was conducted to study the effects of increase in atmospheric CO₂ concentration, changes in precipitation (within ±40%) and increase in temperature (up to +6 °C), by varying these parameters one at a time.. The average annual surface runoff and total nitrogen load decreased by about 8% and 14%, respectively under the perennial grass scenarios when compared to the baseline cotton scenario. The climate sensitivity analysis for the historic period (1994-2009) indicated that the water balances, total nitrogen load, and crop yield were very sensitivity to the changes in climatic parameters. For example, the average annual irrigation water use and evapotranspiration (ET) decreased by 29% and 5%, respectively, in case of cotton when the atmospheric CO₂ concentration was increased from 330 ppm (baseline) to 660 ppm. However, the increase of ambient CO₂ concentration led to an increase in average annual surface runoff, total nitrogen load, and dryland cotton lint yield by about 54%, 28% and 40%, respectively when compared to current CO₂ levels. Similar results were found in case of perennial grasses.

Water Quality and Cost Considerations in the Supply of Feedstocks for Cellulosic Biofuels

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Abstract

As concerns about environmental degradation have increased, identifying cleaner and more environmentally friendly energy sources has become an important focus for the academic community as well as policy makers. Producing biofuels from energy crops is one alternative to fossil fuels with lower greenhouse gas emissions. Cellulosic feedstocks such as corn stover (crop residue), perennial grasses and fast growing trees are promising energy crops that may help with the energy supply.

In this study, we take a spatially explicit approach and examine the conditions under which the agricultural land within a watershed can meet the demand of a biorefinery. Based on SWAT model simulations, we estimate farm production and transport costs of two dedicated energy crops, switchgrass and miscanthus, in comparison to corn stover. We then develop a Matlab program based on a genetic algorithm to minimize production cost subject to biomass production and pollution constraints in the Wildcat Creek Watershed in Indiana, USA.

Our results indicate that the perennial grasses switchgrass and miscanthus have much higher biomass yield than stover harvested from an annual corn crop. However, costs associated with their production, loading-unloading operations and hauling are much higher than those of corn stover. Though corn stover is the lowest cost feedstock considered, it results in relatively higher sediment, nitrogen and phosphorus loading than the perennial grasses considered. There is clear tradeoff among cost, feedstock production, and the level and form of environmental improvement pursued by society.

Keywords

cellulosic biofuels; SWAT; optimization; genetic algorithm; water pollution

Forecasting changes in water quality in the Tennessee River Basin with growing biofuels

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Abstract

This study aims to evaluate how growing cellulosic bioenergy feedstocks in the Tennessee River Basin (TRB) will influence water quantity and quality. We set up the Soil and Water Assessment Tool (SWAT) model for TRB and configure the main reservoirs in the SWAT model as this river basin is highly altered by reservoirs. We used multi-objective optimization to calibrate the water balance component of SWAT against the USGS HUC8 monthly runoff dataset from 1986 to 1995. Another 18-year HUC8 runoff data (1996–2013) were used for model validation. In addition, we employed the same method to calibrate the water quality against the USGS monthly estimated fluxes (sediment, total phosphorus, total nitrogen, and nitrate+nitrite) from 1997 to 2006 and validate the model by the rest data (2007–2013). In general, calibration greatly improved the match between monthly/seasonal patterns in SWAT-simulated and observed historical water quantity and quality data. Based on the calibrated model, we compared simulated water quality between two scenarios, i.e. post-bioenergy future vs. pre-bioenergy baseline. The aforementioned calibrated model is the baseline model with the USDA 2009 Cropland Data layer (CDL) data. The post-bioenergy future scenario will increase the switchgrass land from 0.1% (baseline) to 4%. Median projected nutrient and sediment loadings showed decreases in TRB. Median sediment loadings decreased by 4.4%. Median nitrate and phosphorus loadings decreased by 32.1% and 7.5%, respectively. Preliminary results suggest that TRB holds promise for producing cellulosic feedstocks that enhance water quality.

Keywords

nutrients, runoff, sediment, switchgrass; Tennessee River Basin

Development of a SWAT-based information system to identify areas for sustainable intensive agricultural production in the peninsula of Yucatan, Mexico.

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Abstract

The steady increase in population leads to the need to produce, also steadily, more food. Traditionally, this increase in production has been achieved by opening new lands for cultivation, with consequent deforestation and emission of greenhouse gases, aggravating global warming. As an alternative to produce more food without deforestation, the use of intensive systems of sustainable farming in areas with current agricultural use is proposed. Non-governmental organizations located in the Peninsula of Yucatan, Mexico; They requested to the National Institute of Forestry, Agriculture and Livestock (INIFAP), the development of an information system to support decision-making and planning for sustainable intensive agricultural production systems. The aim of this paper is to present the developed system. The system was developed with information, at municipal scale, of the states of Yucatan, Campeche and Quintana Roo in the Peninsula of Yucatan, Mexico and includes eight watersheds. The developed system includes maps and associated databases. The flowchart of the system provides information (maps and databases) at the municipal, state and basin scale on/for: 1) Characteristics of the agricultural sector, natural resources (water, soil, climate) and socioeconomic conditions. 2) Technologies and their production costs used by farmers. 3) Portfolio of technologies and their costs for intensive production. 4) Maps and databases of crop yields, assessed with the use of SWAT, under the actual technology used by farmers and technology for intensive production (identification of crop yields gap). 5) Protected areas and its territorial ecological zoning. 6) Identification of physical, natural and socioeconomic factors limiting/driving production. 7) Areas for the establishment of development poles with intensive agriculture, highly productive, profitable and sustainable, and 8) Four financial indicators by area and crop. The developed system supports the reasoned decision-making process to select areas and crops for sustainable intensive production of high productivity and profitability, which can help significantly to reduce the rate of deforestation in the peninsula of Yucatan, Mexico.

Keywords

Intensive agriculture, Deforestation, Crop grow modelling, Information system

The Soil and Water Assessment Tool (SWAT) Ecohydrological Model Circa 2015: Global Application Trends, Insights and Issues

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Abstract

The Soil and Water Assessment Tool (SWAT) is one of the most widely used watershed-scale water quality models in the world. Over 2,000 peer-reviewed SWAT-related journal articles have been published and hundreds of other studies have been published in conference proceedings and other formats. The use of SWAT was initially concentrated in North America and Europe but has also expanded dramatically in other countries and regions during the past decade including Brazil, China, India, Iran, South Korea, Southeast Asia and eastern Africa. The SWAT model has proven to be a very flexible tool for investigating a broad range of hydrologic and water quality problems at different watershed scales and environmental conditions, and has proven very adaptable for applications requiring improved hydrologic and other enhanced simulation needs.

We investigate here the various technological, networking, and other factors that have supported the expanded use of SWAT, and also highlight current worldwide simulation trends and possible impediments to future increased usage of the model. Examples of technological advances include easy access to web-based documentation, user-support groups, and SWAT literature, a variety of Geographic Information System (GIS) interface tools, pre- and post-processing calibration software and other software, and an open source code which has served as a model development catalyst for multiple user groups. Extensive networking regarding the use of SWAT has further occurred via internet-based user support groups, model training workshops, regional working groups, regional and international conferences, and targeted development workshops. We further highlight several important model development trends that have emerged during the past decade including improved hydrologic, cropping system, best management practice (BMP) and pollutant transport simulation methods. In addition, several current SWAT weaknesses will be addressed and key development needs will be described including the ability to represent landscapes and practices with more spatial definition, the incorporation of a module specifically designed to simulate rice paddy systems and algorithms that can capture plant competition dynamics such as occur in complex tree/crop systems and interactions between crops and weeds.

Keywords

SWAT, global use trends, technological factors, networking, future development needs

Modeling Sediment and Nutrient Loads Input to the Texas Gulf and Effects of Conservation Practices on Water Quality

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Abstract

Texas Gulf and the surrounding bay areas are experiencing eutrophication/fish kill due to excess nutrients discharged from its draining basin consisting of pastureland, cropland, municipal and industrial discharges and urbanized area. Trinity, Colorado and Brazos river watersheds are also reported to have elevated sediment and nutrient pollution problems. Determining the magnitude of sediment and nutrient loads entering the Texas Gulf from different river basins, identifying their sources, and evaluating the effects of cropland conservation practices on water quality would be useful for planning and prioritizing management efforts for this region. The field-scale model Agricultural Policy Environmental Extender (APEX) was used to simulate the conservation practices on cropland and Conservation Reserve Program land and assess the edge of field water quality benefits. Predicted flow and loads from APEX were input to the watershed scale model, Soil and Water Assessment Tool (SWAT). SWAT was used to simulate the watershed processes and estimate the instream water quality benefits. SWAT model was calibrated for streamflow, sediment and nutrients at multiple sites in the Texas Gulf Basin. These models were then used to (1) estimate the sediment and nutrient loads entering the Texas Gulf from different river basins, and (2) estimate the effects of various cropland conservation practice strategies on water quality in the Texas Gulf Basin. Model predictions indicated that 14.7 million tonnes of sediment, 152,400 metric tonnes of nitrogen and 36,430 metric tonnes of phosphorus loads were entering the Texas from the draining basin as per baseline conservation condition in 2006-06. Currently established practices on cropland were predicted to reduce the sediment, nitrogen and phosphorus losses from edge of field within each 8-digit watersheds by 85%, 32% and 57%, respectively. These practices were predicted to reduce the instream sediment, nitrogen and phosphorus loads entering the Texas Gulf by 19%, 10%, and 6%, respectively. Additional conservation treatment can help to reduce the loads within the basin and to the Texas Gulf.

Keywords

CEAP, SWAT, APEX, Conservation Practices, Texas Gulf, Sediment, Nitrogen, Phosphorus

Assessing spatial and temporal distribution of sediment, nitrogen and phosphorous loading in the Missouri River basin

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Abstract

Two Soil and Water Assessment Tool (SWAT) models were developed to assess spatial and temporal distribution of sediment, nitrogen and phosphorus loading in the Missouri River Basin (MORB). Two sets of the latest land use data of National Land Data Cover (NLCD) and Crop Data Layer (CDL) were used in this study. The MORB SWAT models were calibrated and validated with 20 years of measured stream flow data collected from 20 U.S. Geological Survey stream flow gage stations for watershed hydrology. The calibration of stream flow sediment and nutrient load was based on a subset of the locations used in the calibration of hydrology with limited measured data. Model performance ranges from satisfactory to very good for both calibration and validation periods. The loading of sediment, nitrogen and phosphorus were studied at three scales: subbasin (8-digit hydrologic unit), regional watershed, and the whole basin. Baseline model results showed that the largest total nitrogen and total phosphorus loads come from the subbasins in the Lower Missouri River watershed because of heavily cultivated crop lands. The smallest loads were from the Upper Missouri and Yellowstone River regional watersheds, where inputs from all sources are modest and attributable to the large pasture and range land in this area. The total load delivered to the Mississippi River from the MORB included approximately 6.1×10^7 tons/yr of total suspended sediment, 4.5×10^8 kg/yr of total nitrogen, and 1.0×10^8 kg/yr of total phosphorus. Of these loads, Lower Missouri River regional watershed contributes 30% of the nitrogen, respectively, and 40% of the phosphorus; however, the nitrogen and phosphorus contributions by the Upper Missouri and Yellowstone River regional watersheds were less than 1%. This study further investigated the relationship between land use change and loading of sediment, nitrogen and phosphorus in the MORB. This study will be useful to quantify changes in average sediment and nutrient loads in response to increased biofuel feedstock production in this region.

Keywords

Missouri River, SWAT, land use, sediments, nutrients, water quality, biofuel production

An analysis on the effect of settlements distribution changes to the NPS in the Xiaojiang River Basin after the construction of the Three Gorges Reservoir using SWAT

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Abstract

The Three Gorges Project leads to an aggravation in the level of the reservoir-point source pollution. Exploring the significant factors that intensify the level of the non-point source pollution after the completion of Three Gorges Reservoir (TGR), can be useful for maximizing the social, economic and environmental benefits of the Three Gorges Project. For the construction of the Three Gorges Reservoir, 12,000 migrants have been resettled. The immigration makes the spatial distribution of the settlements been changed from decentralization to agglomeration, along with the pollution discharged way changing from the scattered emission pattern to concentrative emission pattern. Which is one of the significant factors.

Xiaojiang River Basin is the major tributary of the Three Gorges Reservoir, involving four counties, 77 towns. After the construction of Three Gorges Reservoir, the spatial distribution pattern of the settlements has experienced a great change. We assess the effect of the Three Gorges project on the increasing environmental pollution in Xiaojiang River Basin, based on the change of the spatial distribution of the settlements and pollution emissions. With using these data about land use, soil structure, social and economic conditions in 2002 and 2013, the content of total phosphorus, total nitrogen and sediment concentration have been simulated in SWAT model.

The results showed shows that the initial total amount of pollution has varied little after immigration, but the non-point source pollution flow into the water body increased a lot. On the one hand, the hardening of the land inhabited by immigrants leads to the , was not conducive to the infiltration of pollutants reducing, the pollutants directly flowing into the water with the rain from the storm sewer or imported artificial river channels, which lead to an aggravation in the total amount of the non-point source pollutants. On the other hand, after immigration, the both the change from the non-point source (NPS) pollution is collected together and discharge into the river through sewers like the to a point source pollution. Comparing with the dispersive NPS before immigration, the concentrated NPS has smaller losses. While, the , and the unreasonable method on wastewater treatment methods in the area are not enough, which leads to the worse water quality and more amounts of the sewage treatment, centralized sewage inflow discharged through pipes and water channels, which lead to infiltration and reduction loss, thereby increasing the water storage capacity pollutants directly discharging into the water. This study suggested that sewage treatment efficiency should be improved in the TGR areas in order to reduce the amount of pollutant flowing into the Reservoir.

Simulation of Tile Drainage in Two Midwestern Watersheds Using SWAT2012

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Abstract

In many watersheds of the Midwestern U.S., subsurface tile drainage is one of the most important flow pathways and therefore needs to be included in model simulations. SWAT algorithms for modeling flow through tile drains have improved through the years, yet challenges remain for implementing tile drainage simulation, including selection of complex or unmeasurable parameters, and setting up the model to capture outputs at the outlet of the drains. This presentation will describe the tile drain simulation in two small agricultural watersheds, one in Indiana and one in Ohio. The Indiana study showed that curve number values need to be substantially decreased for tile flow prediction and that depth to impermeable layer (DEP_IMP) was the most important calibration parameter, as it also controls seepage through the restrictive layer. In the Ohio study, tile outlet data were available for five tiles, so methods were developed to use each tiled area as a separate subbasin for evaluating tile drainage simulations. These processes have improved the simulation of flow and nutrients in tile-drained watersheds.

Keywords

subsurface drainage, drain flow, nitrogen

Hydrological Modeling of Highly Glacierized River Basins

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Abstract

Soil and Water Assessment Tool (SWAT) was used to simulate five glacierized river basins that are global in coverage and vary in climate. The river basins included the Narayani (Nepal), Vakhsh (Central Asia), Rhone (Switzerland), Mendoza (Central Andes, Argentina), and Central Dry Andes (Chile) with a total area of 85,000 km². A modified SWAT snow algorithm was applied in order to consider spatial variation of associated snow melt /accumulation by elevation band across each subbasin. In the previous studies, melt rates varied as a function of elevation resulting from an air temperature gradient while the snow parameters were constant throughout the entire basin. A major improvement of the new snow algorithm is separating the glaciers from seasonal snow based on their characteristics. Two SWAT snow algorithms were evaluated in simulation of monthly runoff from glaciered watershed: 1) the snow parameters are lumped (i.e. constant throughout the entire basin) and 2) the snow parameters are spatially variable based on elevation band-subbasin (i.e. modified snow algorithm). Applying the distributed SWAT snow algorithm improved the model performance in simulation of monthly runoff with snow-glacial regime, so that mean RSR decreased to 0.49 from 0.55 and NSE increased to 0.75 from 0.69. Improvement of model performance was negligible in simulation of monthly runoff from the basins with monsoon runoff regime.

Keywords

SWAT, Glacier, Snow, Central Asia, South America, Rhone

Modeling Water Quantity and Nutrients in Devils Lake Watershed Using SWAT

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Abstract

Devils Lake, nearly 10187 Sqkm, sub-basin of the Red River basin north, is a terminal lake in northeastern North Dakota. In last two decades, the lake level increased, resulting in connecting to the Stump Lake causing floods that required more than one billion USD for flood mitigation. Devils Lake is already 1.5 meter under its natural spill level to the Sheyenne River from which water is drained through two artificially constructed outlets to prevent flooding, but draining water to Sheyenne river raise a concern of water quality for downstream. In this study, the Soil and Water Assessment Tool (SWAT) was used to simulate water quantity and quality over the Devils Lake watershed between 1995 to 2010. The model was successfully calibrated and validated for the flow, sediment, and total nitrogen (TN) and phosphorous (TP) for the entire of Devils Lake watershed. The results indicated that the average upland sediment, TP, and TN are $0.8 \text{ ton ha}^{-1} \text{ year}^{-1}$, $0.63 \text{ kg ha}^{-1} \text{ year}^{-1}$, and $4 \text{ kg ha}^{-1} \text{ year}^{-1}$. The SWAT model successfully simulated sediment deposition and nutrients in the lake. The result also showed 6.2 meter increased in lake level with RMSE less than 48 centimeter for the study period.

Keywords

Devils Lake, Nutrients, SWAT, Sediment, Water fluctuation

Implications of limited data on sediment yield predictions in a tile drain dominated landscape

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Abstract

The Soil and Water Assessment Tool (SWAT) is commonly applied to estimate sediment yield and predict changes in loads as a result of changes in management or conservation practices at large watershed (>2000 km²) scales. However, challenges in our ability to differentiate between sediment sources in combination with simplifications and omissions of processes render model applications susceptible to systematic biases. As sediment yield computations within SWAT are dependent on flow, it is critical to correctly quantify the water available and the time of its arrival. In that context, proper quantification of the extent, distribution and efficiency of subsurface tile drainage is important in agricultural landscapes. SWAT provides a mechanism to account for sub-surface tile drainage, but in practice actual data to constrain this flow pathway are typically not available. For example, although extensive use of subsurface drainage in Le Sueur River Basin located in south central Minnesota has been documented, the location, density and extents of the tile drainage are generally unknown at watershed scales, leading to uncertainty in flow calibration. In this study we have explored the challenges related to subsurface drainage and its implications for predicting sediment yield. We also demonstrate that it is easy to implicate the wrong source (agricultural fields rather than banks) and suggest approaches to quantify and/or circumvent such problems of equifinality by incorporating independent lines of information, such as sediment fingerprinting data.

Keywords

tile drainage, equifinality

WEPP Model Background, Status, and Current Projects

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Abstract

The Water Erosion Prediction Project (WEPP) model has been developed by the United States Department of Agriculture (USDA) since 1985. The complete validated and documented model was first publicly released in 1995, and the code is maintained by the USDA-Agricultural Research Service, National Soil Erosion Research Laboratory (NSERL), with updates every 2-3 years. WEPP is a process-based model that was designed to estimate runoff, soil loss and sediment yield from hillslope profiles as well as from small field- and farm-scale watersheds up to about 300 hectares in size. Important physical processes modeled by WEPP include infiltration, runoff, percolation, evapotranspiration, detachment by raindrops and by flowing water, sediment transport, sediment deposition, plant growth, residue decomposition, tillage disturbance and soil consolidation, channel erosion, and deposition in impoundments. In addition to the science model (written in Fortran), a variety of databases and interface programs have also been created, ranging from stand-alone desktop PC software, to web-browser based geospatial watershed simulation tools. This presentation will provide background information on WEPP, current model status and development efforts, and implementation projects with cooperating agencies, including the USDA-Forest Service, USDA-Natural Resources Conservation Service, and Iowa State University.

Web-Based Expected Inundation Mapping Using Swat and HEC-RAS Models

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Abstract

There have been many disasters due to floods in the history of the entire world. For example, the 1998 floods in Bangladesh and the flooding in France in 1992 have caused severe damage to life and property. India witnesses every year that millions of people are homeless due to floods. It is one of the worst flood-affected countries being the second in the world after Bangladesh and accounts for one fifth of global death count due to floods. In September 2014, heavy rainfall centred on the North Indian state of Jammu and Kashmir caused devastating floods and landslides in the country's worst natural disaster since the 1944 Kashmir Flood Disaster. More than 700 people were presumed dead. Destruction of bridges and roads left about more than 100,000 pilgrims and tourists trapped in the valleys. Bihar is India's most flood-prone State with 76 percent of the population in the north living under the recurring threat of flood devastation. Plains of north Bihar have recorded the highest number of floods during the last 30 years. Water Resource Department, Govt. of Bihar, India realized the need for developing flood warning system for rivers of north Bihar and has already initiated projects related to real time flood forecasting. The final form of output that is required by the society is the inundation that shall take place on account of the forecasted flood. This information is required in a temporal and spatial manner. This paper aims to develop a system to collaborate on web for exchange of data acquired with help of modern equipments and radars for predicting expected inundation much earlier. SWAT and HEC-RAS models have been used to develop a web-based flood management information network to simulate expected flood inundation maps. HEC-RAS in conjunction with HEC-Geo-RAS is used for hydrodynamic routing and expected inundation mapping. HEC-Geo-RAS was used to extract GIS data for HEC-RAS runs. The main objective of the HEC-RAS program is to compute water surface elevations at all locations of interest, by routing hydrographs through the system. The simulation model creates an import file as input to HEC-RAS. After successful running of HEC-RAS model, longitudinal water surface profile and water surface at each cross section are obtained. For inundation mapping the HEC-Geo-RAS model creates triangular irregular network (TIN) model using the SRTM DEM taking height as data source. A TIN is a set of elevation points which have been connected to form a network of triangles. The TIN module was used for terrain modelling, automated basin delineation and drainage analysis. Flood events of the Bagmati river basin of Bihar, India, have been simulated using hydro-meteorological data downloaded from websites www.imdaws, www.hydrology.gov.np and www.fmis.bih.nic. Flood hydrographs, forecasted by modified SWAT model for 2002, 2004, 2012, 2013 and 2015 flood events were used as initial and boundary conditions for unsteady flow simulations by HEC-RAS model. Expected inundation maps were generated by HEC-Geo-RAS. Simulated water levels were in agreement with measured values and predicted inundation maps were also matching with observed maps derived from RADARSAT imageries.

A Tool to Preprocess the National Soil Database of Canada for SWAT2012

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Abstract

A manual preparation of a usersoil database for large-scale SWAT models is not only daunting, but also an error-prone task. This paper presents the development of an automatic tool that preprocesses a usersoil database from the National Soil Database (NSDB) of Canada. The NSDB consists of polygon attribute table (PAT), soil name table (SNT), and soil layer table (SLT). The PAT contains attributes such as polygon area, perimeter and their polygon id. The SNT describes the physical and chemical parameters of soils that are stored in in the PAT. The SLT contains information which varies in a vertical direction for each soil stored in the PAT. The tool has the capability to extract the required datasets from the NSDB into SWAT2012 format, append the datasets into a usersoil database, and produce a GIS soil map. The applicability of this tool is demonstrated in the Athabasca River Basin, Alberta, Canada.

Keywords

SWAT, Athabasca River Basin, Usersoil, Arctool

Development of Climate and Management Data to Support SWAT Modeling Efforts in the US

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Abstract

Water quality simulation models such as the Soil and Water Assessment Tool (SWAT) are widely used in the US. These models require large amounts of spatial and tabular data to simulate the natural world, including climate and management information. Accurate and seamless daily climatic data are critical for accurate depiction of the hydrologic cycle. Likewise, the assemblage of suitable management data (operation scheduling, fertilization application rates, and plant growth parameterization) is also critical. In the research, we develop national databases for daily climate and management in SWAT format using existing NOAA and USDA data sources. These data are compatible with existing SWAT interfaces, and relatively easy to use. Both datasets were published freely online.

Keywords

Climate, Management

Scheduling field operations as a function of temperature, soil moisture, and available resources

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Abstract

Scheduling field operations in SWAT can be done by specifying fixed dates or by using the heat unit index, which considers temperature constraints. However, soil moisture and labor requirements can also limit the ability of farm operators to perform field operations at the optimal time. The SWAT2012 version 635 code was modified to introduce these constraints. Soil moisture was constrained by a user-defined maximum fraction of field capacity. Labor constraints were represented by limiting field work in the watershed to 1/14th of the watershed worked area, i.e., agricultural land, pasture, and managed forests. This means that in the absence of other field work and assuming that moisture or rain would not introduce any delay, a field operation can be completed throughout the watershed within two weeks. This algorithm was tested in the Goodwater Creek Experimental Watershed, in Northeast Missouri by comparing simulated planting dates of corn and soybeans to 15 years of planting progress records (1992-2006). On average, the model predicted planted amounts of soybeans and corn equal to those recorded within 1 day of the recorded dates for soybeans and 7 days for corn. Differences were larger at the beginning and end of the planting periods. Results indicated the need for a cutoff date beyond which these crops are abandoned and the land is left fallow. Scheduling field operations as a function of temperature, moisture, and available resources will be useful when operation timing is not well known, e.g. large river basins, scenarios analyses, or climate change studies.

Keywords

Field operations, management, scheduling, temperature soil moisture

Defining and Integrating Spatiotemporal Agricultural Land Management into the Soil and Water Assessment Tool

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Abstract

Land cover and land management are important components in the evaluation of hydrologic and water-quality response models used to develop a watershed-based Total Maximum Daily Load (TMDL). The Soil and Water Assessment Tool is a watershed response model used to develop TMDLs due to the model's ability to account for spatiotemporal land cover and management. Accounting for heterogeneous management activities can directly impact the driving forces behind watershed response models including curve number hydrology and phosphorus cycling and subsequently can play an important role in pollutant allocations.

The Wisconsin Department of Natural Resources has developed a methodology that incorporates geospatial data and analysis, county Land and Water Conservation staff knowledge, and field-collected data such as transect surveys to define agricultural management. The land cover and management refinement methodology was applied to agricultural land cover within the 23,714 square kilometer Upper Wisconsin River Basin (UWRB). The result is a spatial layer that defines spatiotemporal variability of agricultural land management, particularly rotation, tillage, and nutrient application for all 64.75-hectare agricultural plots throughout the UWRB between 2002 and 2013. This methodology provides a refined approach that can be used at large scales to support TMDL development, provide a platform for upfront participation from stakeholders, and facilitate TMDL implementation.

Keywords

SWAT Model Development, Agriculture, TMDL, GIS

Using a Single HRU SWAT Model to Examine and Improve Representation of Field-Scale Processes

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Abstract

As a watershed-scale model, SWAT aggregates the outputs from individual HRUs, where a vast number of individual hydrologic and nutrient processes are simulated. While some of these HRU-level processes and associated parameters have been thoroughly tested, others have been assumed from theory or from limited field data. As research advances, new strategies are being developed for the simulation of HRU processes, and these new algorithms and parameter values need to be tested with data that are usually collected on individual plots or fields. Simulating a single HRU is the most efficient method for this evaluation using plot-scale or field-scale measurements, to avoid the effects being masked by aggregating outputs into subbasins. In this presentation, we will demonstrate how a single-HRU model can be created by manipulating ArcSWAT output, and present two examples where such a model has proved useful: (1) evaluating and modifying the tile drain routines using field-scale drainage data, and (2) improving bioenergy crop growth simulation using plant growth measurements on small plots. The single-HRU models have allowed rapid and efficient evaluations of improved algorithms.

Keywords

SWAT Model, Field-Scale, Bioenergy Crops, Tile Drainage

Hillslope hydrology modifications for better representation of variable source areas: SWAT-Hillslope

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Abstract

In hilly landscapes in temperate and tropical humid climates a perched aquifer forming above a relatively impervious soil layer plays a major role in the hydrology, transmitting subsurface flow laterally through the hillslope, controlling soil saturation as the perched water table approaches the surface, providing water for plant use, and influencing biogeochemical transformations related to saturated conditions in soils. In this study, a dynamic perched aquifer and associated water table have been added to the SWAT model using the statistically dynamic (SD) approach used in TOPMODEL and other hillslope hydrology models. As the perched water table rises and falls saturated areas correspondingly expand and contract, and saturation-excess overland flow is generated as precipitation and snowmelt that falls on the saturated soils. The perched aquifer is treated as a non-linear reservoir that can generate rapid subsurface stormflow as the water table rises, with return flow occurring in the saturated areas. The modified *SWAT-Hillslope* model adopts the variable bucket approach for modeling soil water storage capacity. Up to 10 subareas categorized as wetness classes of increasing capacity are identified based on landscape position and incorporated into the delineation of HRUs, and the specified areas and maximum capacities of the wetness classes represent the parameterization of storage capacity distribution for the catchment. The test study in Town Brook Watershed in the Catskill Mountains of New York is presented in this paper.

Keywords

SWAT-hillslope, saturated areas, hydrology, water table

Shaping Lake Erie Agriculture Nutrient Management through a Multi-Model Approach

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Abstract

Harmful algal blooms (HABs) have become endemic to the western basin of Lake Erie. The cyanobacteria *Microcystis* spp. produces toxins that pose serious threats to animal and human health, resulting in beach closures and impaired water supplies, and even forcing a temporary shutdown of the City of Toledo water system for several days in 2014. The main driver of western Lake Erie HABs is high phosphorus (P) loading from agricultural watersheds draining to the western basin, particularly the Maumee River watershed (Maumee). Through the 2012 Great Lakes Water Quality Agreement, the governments of the U.S. and Canada agreed to revise Lake Erie P loading targets to decrease HAB severity below levels representing a hazard to ecosystem and human health. The Great Lakes policy community will soon be faced with determining what policy options are most effective and feasible to address this issue. To better inform the policy community, an interdisciplinary team of policy-makers and watershed modelers was brought together in order to (1) spatially describe P loading from the Maumee, (2) identify potential strategies to reduce P from the Maumee, (3) evaluate the impact of the identified nutrient management strategies using multiple watershed models, and (4) communicate the results of the scenarios to the agricultural and management communities in order to better inform policy.

Keywords

harmful algal blooms, Maumee River watershed, phosphorus, Western Lake Erie Basin, multi-model approach

Bringing SWAT to stakeholders to explore conservation scenario development in the Western Lake Erie Basin

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Abstract

Seasonal hypoxia and harmful algal blooms in Lake Erie have been linked to elevated phosphorus loading from its western basin, and particularly delivered from agricultural runoff in the Maumee River watershed. Historic decreases in total phosphorus loading led to short-term ecological improvements in the lake, but rising fractions of soluble reactive phosphorus are largely blamed for its more recent worsening condition. Many suspect this rise in soluble phosphorus is due to widespread adoption of no-tillage on farmlands artificially drained by subsurface tiles, and there is interest in designing conservation scenarios capable of counter-acting this trend. In this study we consulted with stakeholders in the Western Lake Erie basin to design such conservation scenarios focusing on practices related to nutrient management, soil erosion, and artificial drainage. In initial workshops we presented the capabilities of SWAT for implementing conservation scenarios and assessing their impact on nutrient and sediment loading to Lake Erie, and stakeholders aided modelers in developing scenarios of interest to the conservation and agricultural communities. We ran these scenarios and delivered results back to these stakeholders in follow-up workshops. We are still assessing the full impact of conservation delivered at varying rates of adoption in conjunction with regional climate change.

Keywords

SWAT, scenarios, agricultural conservation, BMPs, Maumee River Watershed, stakeholder engagement

Visualizing alternative pathways for reducing phosphorus loads into Lake Erie

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Abstract

The western basin of Lake Erie has seen a resurgence of harmful algal blooms in recent years. The main driver of HABs has been shown to be elevated phosphorus (P) loads coming from the watersheds that drain into the western basin. Of particular importance is the Maumee River Watershed (MRW), which has been shown to be the main HAB driver. P loading targets, recommended in the Great Lakes Water Quality Agreement, have been developed to keep P levels low enough to prevent HABs. Despite significant work designed to inform these target loads for Lake Erie, less work has been done to identify what policy and management directives are needed to achieve those targets. Our goal was to test the effects of extreme land management scenarios on phosphorus loads to Lake Erie. These scenarios highlight some constraints on phosphorus load reductions that can be achieved from changes in Maumee River Watershed (MRW) management strategies. We evaluate the effects on MRW phosphorus loads under various nutrient management strategies including stopping all fertilizer applications and implanting extreme agricultural management changes. The results indicate that even if fertilizer application on agricultural lands in the MRW ceased entirely, it may take decades to see desired decreases in phosphorus loads. Scenarios results also indicate that there are some potential actions that can be taken in the MRW and potentially other Western Lake Erie Basin watersheds to reduce phosphorus loads into Lake Erie.

Keywords

harmful algal blooms, Maumee River, phosphorus, WBLE

Investigating impacts of BMPs and land use on water quality for sustainable bioenergy production

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Abstract

Nonpoint source pollution is an issue for agricultural fields due to nitrogen and phosphorus from fertilizer and livestock in the Midwest. Land management strategies play important roles in sustainable biofuel feedstock production while minimizing impacts of land use changes on hydrology and water quality. Environmental sustainability of cellulosic biofuel feedstock production was considered to maintain water resources of an integrated landscaping management strategy, through current land use and land management, cropping system, and agricultural Best Management Practices (BMPs). Cellulosic biofuel feedstock production in a landscape design incorporating low productivity land was converted to high biomass production crop such as switchgrass. Agricultural BMPs implementation and source reduction in various combinations were tested to investigate various sediment and nutrient load reduction strategies in a watershed in Iowa, including riparian buffer and winter cover crop application. The Soil and Water Assessment Tool (SWAT) was used to simulate proposed landscape design, riparian buffer and residue harvest/rye applications on sediment, nutrient loadings, and hydrological performance at watershed scale. Results indicate that the effective landscape design and BMPs on current agricultural land can potentially bring marked improvements in water quality and soil erosion control while producing food and fuel feedstock in the South Fork Iowa River watershed. The concept can be integrated with other watershed management programs to improve sustainability of land, water, and ecosystem.

Keywords

BMPs, Landscape design and management, switchgrass, sediment, nutrient, bioenergy production

Best management practices for reducing nutrient loads in a sub-watershed of Chesapeake Bay

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Abstract

Water quality improvement in the Chesapeake Bay is a grave concern. An initiative to reduce the nutrient loads to stream has been undertaken to attain a target total maximum daily load (TMDL) at Chesapeake Bay. A general guideline with a set of best management practices (BMPs) has been in place for the Chesapeake watershed states to be implemented for the TMDL goal. The Chesapeake watershed states have been directed to sub-divide the allocations of the TMDL by local areas, but for more effective allocations of the BMPs a field-scale implementation plan is needed. Spring Creek watershed of Centre County, Pennsylvania was chosen in this study for investigating the effectiveness of the BMPs and deriving an implementation plan using the Soil and Water Assessment Tool (SWAT). The SWAT model is capable of assessing the effects of field-scale BMPs on watershed discharge estimates under inter-annual and seasonal variations of temperature and precipitation. Recorded weather and streamflow data, and 10-m digital elevation maps, and SSURGO soil data were used to calibrate and validate the model. Since base-flow is a major component of streamflow in Spring Creek, the most sensitive calibration parameters affecting model performance were base-flow factor, curve number, and surface water to groundwater transport delay factor. The model adequately described hydrologic processes with a Nash-Sutcliffe coefficient of 0.76 and a coefficient of determination of 0.75. The model has finally been used to prepare a set of effective field-scale BMPs to cut 20% of the nutrient loads as allocated for the watershed by 2025. The next step will be in assessing field-level cost-effectiveness of the BMPs.

Keywords

best management practices, field-scale, Chesapeake Bay, TMDL, WIP

Using GIS Technology to Inform Watershed Modeling and Conservation Practice Implementation at the Local Level

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Abstract

Watershed models such as SWAT and HSPF are often used to provide information needed to guide water quality management decisions at the watershed and regional scales. These decisions include providing estimates of the load reductions associated with the implementation of conservation practices. However, local practitioners responsible for selecting and implementing on-the-ground conservation practices often lack the technical resources needed to utilize model outputs to inform decisions about the locations, numbers and water quality benefits of the practices needed to meet water quality goals. The use and advance processing of high resolution topographic data (i.e. collected using LiDAR technology) provides an opportunity to target practices at finer scales and inform watershed modeling efforts. This presentation will highlight how the Prioritize, Target, and Measure Application (PTMApp) has been developed as an ArcGIS toolbar to identify field scale locations that are suitable for conservation practices , and estimate their resulting load reductions (nitrogen, phosphorus, and sediment) to downstream lakes and rivers.

Keywords

BMPs, Terrian Analysis, GIS, LiDAR, Implementation Strategies

Challenges defining functional evaluation of an ungauged headwater wetland in coastal AL

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Abstract

In this study, we evaluated the water quality and flow mitigation capability of relatively understudied headwater wetland systems located in south Alabama's coastal plain region. For this we explored the use of SWAT coupled with a wetland nutrient cycling model called WetQual. Observed flow and nutrient data for the study headwater wetland exists for first flush events over a 5-month period from Aug 2013 through January 2014. Due to lack of continuous data, we used SWAT to simulate daily-scale wetland inputs which were calibrated with observed data. SWAT has been previously calibrated for watersheds in the region such as those of the Fish River, Magnolia River and the Wolf River; model parameters from these studies were used for the purposes of our study. When we compared SWAT simulated watershed flows to the wetland with observed data we observed that SWAT greatly underestimated the extent of groundwater contributions to the wetland. This study outlines our challenges in figuring out the best way to couple these models while still generating ecologically relevant understanding of the headwater wetlands nutrient mitigation capabilities. Baldwin County, AL, has seen a fast rise in coastal development, and this trend is expected to continue significantly in the future. This imperils headwater streams and wetlands which occur numerously on this landscape. With the Gulf of Mexico already undergoing large problems with nutrient eutrophication, assessment of the functioning of these numerous headwater systems becomes critical in water quality and flow maintenance in the region.

Keywords

wetland, groundwater, nitrogen

Using the Soil and Water Assessment Tool to provide critical spatial information about the magnitude of water quality stressors and their effect on stream biodiversity

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Abstract

Non-point source (NPS) pollution is a major driver of stream degradation and threatens valuable coastal ecosystems. Despite widespread awareness of this issue, conditions in many areas continue to worsen. One factor limiting effective NPS pollution management is the lack of information at fine spatial resolutions across broad spatial extents. In particular, detailed spatial information about the *effects* of NPS pollution on biodiversity is lacking. This spatial information is integral to allocating limited resources strategically. We developed a hydrologic model at the 1:100,000-scale using the Soil and Water Assessment Tool to assess water quality conditions in Western Lake Erie tributaries. We linked this water quality data to observed fish community data, which were available for a subset of the watershed, to develop models of fish community responses to water quality stressors. We then forecasted biological conditions across the whole watershed. We found that depending on the fish metric considered, between 3 %and 29% of the watershed is highly limited by water quality. We attribute between 72% and 100% of this impairment to agriculturally generated NPS pollution. Importantly, the amount of impairment varied among sub watersheds, often characterized by positively skewed or lognormal probability distributions. We used these skewed distributions to identify priority watersheds for conservation action across multiple spatial scales. By coupling hydrological and biological models, we can provide critical spatial information about the *effects* of NPS pollution on stream biodiversity. This spatial information is essential for effective conservation with limited resources.

Keywords

biotic integrity, watershed conservation, nutrients, suspended sediment, river

Development of a Distributed TMDL Allocation in Liangzi Lake Basin Using SWAT Model and Water Quality Model

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Abstract

The Liangzi Lake is the important ecological water sources and one of the biggest fresh water lake in Hubei province, China. There are seven rivers, including Gaoqiao River, Xujiaguang River, Jinniuguang River and etc., flow into the Liangzi Lake and 16 counties with different social development level that located in the Liangzi Lake basin. The non-point source (NPS) is the main pollution source in Liangzi Lake recently, in which the disordered agricultural structure and no standards fertilization have become main factors that damages the environment of Liangzi Lake. To control the NPS, researches about the allocation total of contaminations are urgent need. The total maximum daily load (TMDL) is one of the most important program on the total pollutant control, which has great significance for controlling pollutant discharge, distributing total amount and protecting the environment. To protect and improve the environment in Liangzi Lake, this paper presented the TMDL in Liangzi Lake based on the SWAT model and the water quality model for lake.

For TMDL plan, the main processes are calculating the external loadings, computing internal loading and analyzing the margin of safety (MOS). In this paper, the SWAT model has been used for NPS modeling (as external loadings). The COD, TN, TP have been selected as the allocation factors for TMDL and the Liangzi Lake basin has been divided into seven sub-basins and 16 administration cells according to its river structure. The two dimensional model has been used for water quality simulation in the lake (as the internal loading) with using the results of the SWAT model as the boundary intake conditions. With these simulation results, the primary allocation and secondary allocation of TMDL in Liangzi lake basin have been done. The results shows that the pollutant loads in Liangzi Lake need redistribution and should be cut down. In which, the pollutant loads from Gaoqiao river sub-basin should be cut down 40%, and the Xujiaguang sub-basin should be cut down 30%, while the other five sub-basins remaining don't need abatement. The SWAT model coupled with the water quality model are good tools for TMDL program.

Keywords

TMDL Allocation, SWAT, Water Quality Model, Liangzi Lake

Large-scale, NHDPlus Resolution Watershed Modeling in the Western Lake Erie Basin Using SWAT

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Abstract

In recent years, increasingly large amounts of measured data are available for scientists and engineers to conduct analyses and watershed-scale simulations on challenging topics, such as water resources allocation, sediment transport, and pollution control. To enhance the quality of model predictions, both temporal observation data (Hard Data) and intra-watershed behavior (Soft Data) are considered during the model calibration/validation procedure. In addition, application of finer resolution data is one of the alternatives enabling modeling projects to be more representative. In this study, Soft/Hard Data are incorporated with the state-of-the-art National Hydrography Dataset (NHDPlus) to simulate hydrologic, sediment, and nutrient processes in the Western Lake Erie Basin (WLEB). In addition, conservation scenarios are simulated, alongside predicted potential costs associated with scenario implementation. The results indicate that increased investments could provide better performance in terms of reducing nutrient and sediment loads. However, case scenarios with higher investment costs, such as Nutrient Management, may be less feasible in the real world because available financial resources are potentially limited. Therefore, case scenario with some efficacy and less cost (e.g., Erosion Control) may be the primary recommendation in practice.

Keywords

NHDPlus; Soft Data; Model calibration; IPEAT; SWAT

Analyzing the Variability of Water, Sediment and Nutrient Fluxes within an Agricultural Watershed to Identify Nutrient “Hotspots”

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Abstract

Approximately 50% of suspended solids and nutrients are delivered to Western Lake Erie from the agriculturally dominated Maumee River Watershed (MRW [\[M1\]](#)). Cropping patterns, soils, subsurface drainage, changing weather patterns and runoff potential have been identified as major natural and human factors impacting nutrient delivery to the Lake. Although, nutrient dynamics at the MR outlet are well-studied and documented through monitoring and modeling, the spatial and temporal dynamics within the MRW are poorly understood. Spatial variability in soils, cropping and local storm patterns heavily influence runoff potential from various sub-watersheds. Identifying areas, or sub-watersheds, with high runoff potential that are a major source for suspended solids and nutrients, would be extremely helpful to guide the application of best management plans (BMPs). For this reason, we performed a multi-site calibration and validation of a MRW Soil Water Assessment Tool (SWAT) model to evaluate the spatial and temporal variability of water and nutrient fluxes within the MRW. Flow calibration was completed at nine stream flow locations and validated at thirteen locations within MRW. Water quality parameters (suspended solids, total and reactive phosphorus and nitrate-nitrogen) were calibrated at the outlet of MR and validated at three internal locations. Initial results indicate that the interannual variability of stream flows are greatest at gage locations that drain high-runoff potential areas. These poorly-drained areas with intensive corn-soybean crop rotations and extensive subsurface drainage contribute larger proportions of surface and subsurface runoff and subsequently nutrients. Our findings identify the need to understand and locate the high-risk source areas when developing and implementing best management practices for nutrient reduction in the MRW.

Use of a calibrated SWAT model to support best management practice (BMP) evaluations in the Maumee River watershed

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Abstract

The Maumee SWAT (MASWAT) model is a calibrated, HUC-12 scale model covering the 6,575 square mile drainage area of the Maumee River, a largely agricultural basin located in Michigan, Ohio, and Indiana which ultimately drains to the Western Basin of Lake Erie. Western Basin cyanobacteria bloom modeling work has demonstrated that the Maumee River spring (March – July) phosphorus load is the major driver of the Harmful Algal Blooms (HABs), prompting the need for development of BMP strategies that will accomplish the necessary watershed load reduction. Therefore, the intended use of the MASWAT model is the evaluation of best management practice (BMP) scenarios to determine their potential to reduce spring loading to the lake.

LimnoTech began with the publically available Ecofore SWAT2005 model developed by Bosch et al. (2011) and updated the database parameters to version SWAT2012. Additional climate data was provided so the model would run through 2014. Detailed agricultural management data was obtained from the ARS's CEAP model of the WLEB. These management data were aggregated to a HUC-08 level and applied to the MASWAT model to provide a more accurate representation of management practices across the watershed. Finally, the model was re-calibrated for the 1998-2010 period for hydrology using the new tile drain parameters and for nutrients with a focus on phosphorus. Additional calibration stations upstream of Waterville were added to further constrain model predictions. The model was then confirmed and applied using the time period 2005-2014.

LimnoTech staff will utilize this model to support the University of Michigan's Water Center in their Western Basin Lake Erie Scenario project work. In this project, a suite of five SWAT models with harmonized baseline climate inputs and an application of the SPARROW model will be employed to predict watershed responses to a variety of BMP scenarios, both 'extreme' and 'bundled'. This presentation will highlight the results of LimnoTech's MASWAT model responses to 'extreme' BMP scenarios implemented across the watershed. Results for the time period of 2005-2014 will focus on the effect of actions on the loading of phosphorus to the lake, the endpoint of concern for this evaluation.

Keywords

SWAT, BMPs, Watershed Load Modeling, Lake Erie, Phosphorus

The implications of SWAT parameter equifinality on climate change projections

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Abstract

Through the use of General Circulation Model (GCM) output or climate sensitivity scenarios, the effects of climate change on water resources have been studied extensively throughout the world. This presentation will examine the concept of Soil and Water Assessment Tool (SWAT) parameterization uncertainty or equifinality, where many unique hydrologic model parameter sets can result in adequate calibration and validation statistics, on hydrologic projections from downscaled GCMs for three snowmelt-dependent watersheds in the western United States (upper reaches of the Clearwater, Gunnison, and Sacramento River watersheds). For each watershed five sets of calibrated parameters based on adequate calibration and validation statistics are assessed. Despite similar model efficiency statistics, a majority of average annual streamflow projections during the 2080s were significantly different, with differences in magnitude (increase or decrease) and direction compared to historical annual streamflows. At the average monthly timestep, a majority of projections varied in peak streamflow magnitude/timing and summer streamflows, as well as overall increases or decreases compared to the historical monthly streamflows. Snowmelt projections also varied, both in depth and snowmelt peak timing, for all watersheds. Since a large portion of the runoff-producing regions in the western United States (and many other regions throughout the world) are snowmelt-dependent, this has large implications for projections of the amount and timing of streamflow in the coming century. This work shows that hydrologic model parameterizations that give similar satisfactory calibration and validation statistics can lead to statistically significant differences in hydrologic projections.

Keywords

climate change, streamflow, snowmelt, parameter uncertainty, calibration, equifinality

Projecting climate change impacts on surface hydrology of a small agriculture-dominated watershed

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Abstract

The Skunk Creek watershed is an agriculture-dominated watershed where water demand for agricultural production is mainly met by the flow generated in the Skunk Creek. Therefore, it is crucial to estimate future water availability for sustainable agricultural production in this watershed. The objective of this study was to project the climate change impacts on water availability to estimate potential drought periods. We used the process-based distributed Soil and Water Assessment Tool (SWAT) model and calibrated for a period from 1987-1994 with *NSE* and *R*² values as 0.84 and 0.84, respectively, for monthly streamflow simulations. The future climate scenarios were simulated using the average outputs of temperature and precipitation obtained from Special Report on Emission Scenarios (SRES) (B1, A1B and A2) of general circulation models (GCMs) for mid-21st century. We estimated higher surface runoff in all future scenarios that led for higher stream discharge in the basin. The maximum (93%) increase in surface runoff was estimated for the SRES-B1 and minimum (38%) was estimated with SRES-A2 compared to baseline. Similarly, maximum (236%) and minimum (184%) change in stream discharge was estimated with SRES-B1 and SRES-A2, respectively. However, a negative increase in stream flow values ranging from 4-90% was observed for the period crucial for crop growth in 2058 and 2059 for all the emission scenarios compared with baseline. This may lead to decline in agricultural productivity because of limited water resources. These potential hydrologic variations may largely influence the agricultural production in the basin. Therefore, an accurate assessment of uncertainties associated with future climate scenarios need to be studied carefully for making more precise and reliable decisions on water conservation strategies during agricultural drought periods.

Keywords

Climate Change, Stream flow, Runoff, SWAT, Drought

Modeling the potential impacts of climate change on streamflow in a headwater basin of the Grande River Basin, Southeastern Brazil

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Abstract

The assessment of the potential impacts of climate change on streamflow is important to support the water resources management in countries like Brazil, where 70% of the electric power is supplied by hydropower plants. The objective of this study was to calibrate and validate, in monthly basis, a headwater basin of the Grande River Basin, Southeastern Brazil, in order to evaluate the impacts on hydrology under future climate change scenarios. For this purpose, precipitation and maximum and minimum temperatures data sets simulated by Eta, a regional climate model, nested in the global climate model HadGEM2-ES considering the RCP 4.5 and 8.5 scenarios, were forced through the SWAT model. The simulations were carried out in three time slices (2007-2040; 2041-2070; 2071-2099) and compared to the simulation of the baseline period (1961-2005). The results showed an increase in the maximum (4.76 and 6.61°C) and minimum (0.60 and 1.75°C) temperatures and a decrease in the precipitation (9.16 and 16.58%) for both scenarios (RCP 4.5 and 8.5), respectively. Yet, the results led to a significant reduction of the streamflow and therefore a reduction of the annual water yield for the three time slices, showing a decrease of 35.5, 21.1 and 23.3% and 29.8, 26.5 and 40.1% for the RCP 4.5 and 8.5 scenarios, respectively, when compared to the baseline period. Thus, the hydrological behavior of the watershed may be negatively affected, especially the ground water recharge capabilities and therefore the base flow, reducing the water availability of the region in the dry periods.

Keywords

Climate change, Eta-HadGEM2-ES model, SWAT model.

Impacts of model parametric uncertainty on landuse planning decision making

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Abstract

Watershed scale simulation models are used to evaluate various 'what if' questions and to make informed decisions. These mathematical models include many empirical and/or non-empirical parameters to represent various eco-hydrological processes. Parameter uncertainty is a major issue in mathematical model simulations, as often the actual parameter values are not available or are measurable. The model parameter uncertainty can affect simulation results and consequent decisions. The objective of the study was to evaluate parameter uncertainty of Soil and Water Assessment Tool (SWAT), and to evaluate potential impacts of uncertainty in model simulations on the decisions suggested for land use planning. An optimization based land use planning case study was developed to identify optimal cropping pattern including bioenergy crops in the St Joseph River watershed, IN, USA. The objective function for land use optimization included biomass production of 3,581 metric tons per day (under thermochemical conversion) minimum feasible production for a biomass processing plant, with minimum biomass production cost and maximum environmental benefits. Parameter uncertainty of the SWAT model is assessed using Shuffled Complex Evolutionary Metropolis Algorithm (SCEM). Five representative parameter sets were selected from the prediction uncertainty interval to represent the parameter uncertainty. The SWAT model was linked with AMALGAM optimizer to derive at an optimal cropping pattern for the watershed. Five sets of land use optimizations were conducted considering the five sets of parameter values, and the effects of parameter uncertainty on optimization results were quantified. The preliminary results showed that the simulation optimization results had some level of uncertainty that needed to be included in making land use decisions for bioenergy crop production.

Keywords

Parameter Uncertainty, optimal landuse planning, bionenergy production, AMALGAM, SCEM

Reducing equifinality in semi-distributed models by using spatial wetness information and reducing complexity in the SWAT-Hillslope model

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Abstract

Estimating model parameters in simulation models can be problematic because of the non-linearity and interdependence of the parameter sets since changes of some parameters might be compensated by others. It is not uncommon when calibrating distributed hydrological models against discharge at the basin outlet to find multiple parameter vectors with reasonably good performance. This is known as equifinality which contributes to uncertainty of model predictions. Equifinality for semi-distributed hydrological models may be reduced by employing conceptually appropriate models, calibrating with both spatial and temporal observations, and by reducing complexity. We will apply our conceptual model to the Catskill Mountains (New York State) where subsurface connectivity determines the wetting pattern in the landscape. The model used is SWAT-Hillslope, a modified version of SWAT that incorporates topographic characteristics in Hydrological Response Unit (HRU) definition and introduces a perched water table with the ability to route interflow from “drier” to “wetter” HRU wetness classes. Calibration of discharge at the outlet of the watershed with SWAT-Hillslope was carried out by randomly generating a large number of parameter sets using the Monte Carlo sampling method. The preliminary result shows that SWAT-Hillslope could predict discharge well with Nash-Sutcliffe Efficiency of more than 0.6 and 0.8 for daily and monthly time steps, respectively, and was not affected significantly by reducing the HRU number. As expected, multiple parameter sets could be identified that performed equally well in predicting outlet discharge in the calibration period, but resulted in diverse performances in the validation period. Constraining the parameters further with available spatial information on moisture contents and location of saturated soils reduces equifinality. We expect improved model performance by adjusting the model structure to better represent the landscape and by reducing complexity and equifinality.

Keywords

Equifinality, Model complexity, SWAT-Hillslope, Uncertainty

Modeling Irrigation Systems in Semi-Arid Regions: Current Status and Emerging Needs for SWAT

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Abstract

Major hydrologic and environmental issues faced in irrigated stream-aquifer systems in semi-arid climate regions include rising water tables, nutrient leaching to the water table, mobilization of trace metals from outcropped and bedrock geologic material, and loading of salinity, nutrients, and trace metals from the aquifer to surface water via diffuse groundwater discharge and tile drains. Rising water tables induce waterlogging and soil salinization, which in turn decrease crop yield and, if left unchecked, eventually render the soil unusable. This presentation highlights these issues with reference to previous and ongoing research projects in the Lower Arkansas River Valley (LARV) in southeastern Colorado and South Platte River Basin (SPRB) in northeastern Colorado, and outlines needed modeling capabilities of the SWAT model if it is to be used effectively in these and similar river basins. Specific capabilities include simulating shallow and temporally-dynamic water table elevation, simulating flow and solute transport through tile drainage networks, representation of irrigation pumps throughout the aquifer, groundwater flow to surface water bodies, and spatially-dependent loading of salinity and other chemical species from the aquifer to the stream network. Of utmost important is the ability to simulate the fate and transport of salt ions through the land surface – soil – aquifer – stream continuum.

Simulating establishment period of perennial bioenergy grasses in the SWAT model

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Abstract

Perennial bioenergy grasses, such as switchgrass and Miscanthus are considered to be important cellulosic biofeedstock sources. However, these grasses require multiple years to fully establish before their full biomass production potential can be realized. An understanding of growth processes for these crops are limited resulting in a general ignorance of hydrologic/water quality impacts during the establishment period using crop growth models. This study evaluated the length of establishment period and the trends of biomass, Leaf Area Index and biomass partitioning ratio to above and belowground biomass during the establishment period of the two perennial grasses. The identified trends were then incorporated into the Soil and Water Assessment Tool model to improve the model's capability to accurately represent their growth process and evaluate the hydrologic and water quality impacts. Based on yield data, average yield that established grasses are expected to produce was recommended to be used as a yield threshold (10 Mg/ha for upland switchgrass, 15 Mg/ha for lowland switchgrass and Miscanthus in Europe, and 20 Mg/ha for Miscanthus in the U.S.) for determining length of establishment period. Based on these yield threshold, establishment periods of switchgrass were 2 to 3 years for both upland and lowland switchgrass. Establishment periods of Miscanthus were 2 to 4 years in the US and 3 to 6 years in the Europe. Modified SWAT model provided an acceptable simulation of yield data trends at 4 different sites. Evapotranspiration tended to be smaller, increasing surface runoff and water yield during the establishment period than the established period. Soil erosion and nutrient loss will also be higher due to smaller biomass production and poor land surface protection, especially during the first year.

How do climate change and bioenergy crop production affect watershed sustainability

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Abstract

Sustainability analyses of plausible land use scenarios are critical in making watershed-scale decisions. In USA, Bioenergy-driven land use/land management changes raise concern over potential environmental impacts, both in terms of water availability and water quality. These potential impacts may be exacerbated by climate variability and change. The overall goal of this study was to assess environmental, economic and biodiversity sustainability of plausible bioenergy feedstock production and climate change scenarios. The study considered fourteen sustainability indicators under nine climate change scenarios from World Climate Research Programme's (WCRP's) Coupled Model Intercomparison Project phase 3 (CMIP3). The SWAT model was used to simulate perennial bioenergy crops such as *Miscanthus* and switchgrass, and corn stover removal at various removal rates and their potential impacts on hydrology and water quality. Aquatic biodiversity was estimated using Species Distribution Models (SDMs) developed to evaluate stream fish response to hydrology and water quality changes. The watershed-scale sustainability analysis was done in the St. Joseph River watershed the Wildcat Creek watershed, located in the Midwest USA. The results indicate improved sustainability indicators corresponding to water availability and quality. Biodiversity indices also indicated improved fish distribution with perennial energy cropping systems compared to conventional cropping systems (maize-soybean). Water quality benefits due to land use change were generally greater than the effects of climate change/variability.

Keywords

Sustainable bioenergy production, climate change, landuse change, bioenergy

Assessment of Bioenergy Cropping Scenarios for the Boone River Watershed in North Central Iowa, United States

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Abstract

The Boone River Watershed (BRW) is an intensively cropped region dominated by corn and soybean production that covers over 237,000 ha in north central Iowa. The BRW is reflective of both current Iowa cropping trends and elevated levels of nutrient pollution in streams. Nitrate losses are of particular concern, much of which escapes the cropland via subsurface tiles that drain the predominantly flat landscapes that characterize the watershed. Phosphorus export to stream systems in the BRW is also a problem of considerable concern. Questions have emerged as to the possible impacts of adopting cellulosic biofuel production systems in Iowa watersheds such as the BRW, which would be developed as function of corn stover removed after harvest or via the introduction of perennial biofuel crops such as switchgrass and miscanthus. In response, a modeling system been constructed for the watershed using the Soil and Water Assessment Tool (SWAT) model to address biofuel-related water quality and related issues. The specific version of SWAT (SWAT version 2012; Release 615) that is being used in the study features recent modifications made to the source code that corrected inaccuracies in previous codes in regards to simulating removal of corn stover and also the growth of switchgrass and miscanthus. In addition, updated crop growth parameters that more accurately represent the biomass production potential of switchgrass and miscanthus varieties being grown in the U.S. Corn Belt region are being used in this SWAT modeling system. The results of several scenarios are reported here that reflect future cellulosic biofuel scenarios based on 20%, 30% or 50% removal levels of corn stover or widespread adoption of switchgrass and/or miscanthus across parts or all of the BRW. Both hydrologic and pollutant loss (sediment, nitrogen and phosphorus) losses are reported for all of the simulated scenarios.

Keywords

Cropping systems, corn, switchgrass, miscanthus, stover removal, SWAT, nutrient pollution, tile drainage

Assessment of Large-Scale Bioenergy Cropping Scenarios for the Upper Mississippi and Ohio-Tennessee River Basins

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Abstract

The intensely row-cropped Upper Mississippi River Basin (UMRB) and Ohio-Tennessee River Basin (OTRB) form the Corn Belt Region in the Midwestern US, which, according to the US Environmental Protection Agency, is considered the key contributing area of nutrient pollution to waters, responsible for the Northern Gulf of Mexico hypoxic zone. On the other hand, this area is traditionally of utmost importance for the agricultural economy of the country and promising for its future cellulosic bio-economy. Thus, there is an urgent need to explore how future biofuel production in this area can coexist with a healthy water environment downstream. To this end, we used an integrated modeling system of the Corn Belt, already constructed with SWAT (SWAT version 2012; Release 615) based on a 12-digit hydrologic unit or 'subwatershed' delineation. As a starting point on an extensive scenario testing in the area with this large-scale hydrologic model, three cellulosic biofuel scenarios are tested: a) 50% corn stover removal from all the corn-soybean and continuous corn land with slopes <2%, b) the Switchgrass Shawnee growth to all cropland with slopes >2% and to all pastureland and c) the cultivation of Miscanthus to all cropland with slopes >2% and to all pastureland as well. The model is executed for a recent 20-y period and the results are evaluated based on SWAT outputs on an annual basis. Hydrology is not practically influenced compared to the baseline, however, sediments from HRUs entering streams have been significantly reduced under the growth of both perennial crops but not under the stover removal scenario, which caused an expected slight sediment increase. A similar output is produced for P, which is strongly connected with sediments in SWAT. On the other hand, all scenarios resulted in reduced N losses to streams and rivers which are reflected to a considerably reduced N load in the Mississippi river downstream. Crop and biomass yields were also estimated across the landscape and based on the updated SWAT growth routines for perennials they are very promising for biofuel production. It is believed that SWAT water quality and yield estimations presented herein along with a detailed economic assessment of changing the landscape to perennial biofuel crops and/or managing collected stover can guide policy makers towards a sustainable biofuel production plan across the Corn Belt.

Keywords

Biofuel scenarios; Cropping systems; Large scale; OTRB; SWAT; UMRB.

Enhancing Prediction Accuracy in the Bagmati River Flood Forecasting Model on MIKE11 Platform in India

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Abstract

The Indo Gangetic Plains are almost every year visited by floods during the monsoon season when it rains heavily on the lofty Himalayas and the fast depleting woodlands in the valley commonly known as the Terai. The rivers that originate from Nepal, Tibet and China on the Himalayas are perennial because the snow line continues to melt during summer season with the winters being seasons of lean flow. They flow southwards forming the three major drainage system- the Indus draining into the Arabian Sea, the Ganges draining into the Bay of Bengal and the Brahmaputra draining into the Bay of Bengal. The River Bagmati originates in Nepal and passes through its capital Kathmandu and enters India near Dheng and flow south easterly to outfall in River Kosi, a major tributary of Ganges System. Traditionally it has been known as the Sorrow of the northern State of Bihar. It is known to have destroyed thousands of lives since time immemorial. It was only during the British rule in India that a sincere effort was made to tame the river by reducing the fury of floods with the construction of parallel embankments, construction of bridges, raising the canal system by construction of weir schemes and barrage to divert the floods for irrigation purposes. This reduced the loss of life and damages to property to some extent in the flood plains of North Bihar. A chain of flood gauge stations were set up during the British period and system of metering the River Bagmati started. The trend was further followed after Independence with a number of rain gauge stations having been set up in Nepal and India in the catchment area of the River Bagmati with the intent of forecasting the floods manually so as to give enough lead time for preparation to tackle flood situation and to reduce the loss of life and properties at Bihar in India. The Water Resources Department (WRD) of the Government of Bihar (GoB) although makes sincere efforts in obtaining the discharge and rainfall data as quickly as possible through the diplomatic channel yet it leaves the WRD flood managers with hardly 24 hours of lead time to tackle floods in the flood plains of River Bagmati in Bihar. There was a pressing need to enhance the lead time and a consensus evolved in the WRD to automate the Bagmati Flood Forecast by clinching the latest advances in the field of Information Technology and Multimedia by modeling the Bagmati flood scenario on a computer system using simulation to automatically generate the flood forecast with at least 3 days of lead time with more than 95% accuracy. Dennish Hydraulic Institute (DHI)'s MIKE11 Platform qualified as the natural choice because it had already modeled the Bagmati in the Nepal portion and has also been actively involved in modeling the Brahmaputra River in other Indian states as well as in Bangladesh. Its attractive interfaces reflecting the elegance of its presentation logic coupled with an equally efficient algorithm based robust business logic bears an edge over the other modeling software. It has been developed over the .net framework that supports Microsoft's Windows Operating System and is user friendly, secure as well as being network compatible. MIKE platforms can read data from Excel files and presents various graphics and tables as the output. It can handle voluminous input data, can process them at a very fast rate and can present output in the desired format. The paper describes the prevalent system of manual flood data gathering

from various gauge sites in India by Central Water Commission (CWC) and WRD on Bagmati and its tributaries and how they are compiled by WRD for an onward transmission to flood managers, disaster managers and other stake holders for further actions. The manual system is based on various empirical formula that determine the hydrology of the Bagmati Adhwara group of rivers as well as India Meteorological Department (IMD) rainfall forecast data for the basin and an examination of the accuracy in manual flood forecast on a particular gauge site at Benibad on Muzaffarpur Darbhanga four lane highway for the flood season of 2013 was found to be 94.9%. However most of the manual flood forecast accuracy is found in the normal range of 85% to 90%. This study tries to look into the problems of low accuracy in automated flood forecast that is common in recently introduced Real time flood forecasting in Bagmati Adhwara river basin on MIKE11 platform by WRD. The model was fine tuned by iterating a number of times with historical data so that the input variable initialization is fine tuned by reengineering some of the output as input variables. It was only after 6 iterations on historical data set that the model was calibrated to meaningful accuracy. The model was further improved by dividing the river into seven reaches having different Manning's N values as compared to the traditional three reaches with different N values. Thus by playing with the Manning's N values and running a number of iterations the automated flood forecast prediction accuracy was enhanced to around 97.7% on the same data set as used in manual flood forecasting, a significant improvement from the present manual system in Bagmati River Basin in North Bihar. It is expected to yield even better accuracy as the model is calibrated with real time data in future as the WRD is in the process of installing the Real Time Data Acquisition System (RTDAS) in the Bagmati and its tributaries.

Keywords

MIKE11, DHI, WRD, GoB, RTDAS, CWC, MoWR, GoI, Manual flood forecasting, Automated flood forecasting, Flood forecasting accuracy, GIS, Remote Sensing, Modeling and Simulation.

Using SWAT Module in the Design of Submerged Weir on Narrow Rivers Having High Flood Discharge

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Abstract

Weir is a diversion structure built across a river for diversion of water for irrigation purposes. For hydraulic design of weir, scour depth is determined using the discharge intensity formula. In case of narrow rivers with high design discharge, the discharge intensity becomes very large and consequently the depth of sheet piles become huge when based on conventional standards guidelines of the Bureau of Indian Standards (BIS). It makes the design of cut off economically not viable. Especially when the command is small the B/C ratio becomes adverse. Moreover containing the floods between the afflux embankments is not advisable. An innovation with the SWAT flood routing module can be made for calculating the discharge intensity and scour depth and for passing the maximum flood discharge safely. SWAT assumes width of river in flood plains to be 5 times the width of river. A submerged weir (Pantit) on river Punpun in Bihar, India has been designed for depth of sheet pile, which was determined using the SWAT concepts. The depth of sheet piles so determined was found techno- economically feasible. Accordingly suitable amendments in the BIS Code of Practice for design of submerged weir are being recommended.

A Web Based Interface for Distributed Short-Term Pollution Potential Forecast: Coupling SWAT with the Global Forecast System Model

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Abstract

Non-point source (NPS) pollution from agricultural activity is a major source of surface water quality impairment in the Chesapeake Bay region. Surface hydrology in this area is highly variable over short time periods and creates areas with widely fluctuating spatial and temporal pollution potential. The influence of these variable source areas (VSA) is not captured by long-term quantification methods aimed at informing agricultural management decisions to reduce NPS pollution. The F-SWAT framework has shown potential in providing distributed hydrologic forecasts at the necessary spatial and temporal resolution to predict the pollution potential of VSAs. However, the methods aimed at delivering this information to users is not accessible when limited to software and technology that requires time and training to use. A prototype of a web-based interface displaying distributed hydrologic forecasts is introduced in this study. The goal of this interface is to provide easily accessible, real-time pollution potential forecast maps that provide users a means to avoid high-risk areas when planning agricultural practices. The prototype forecast system consists of two major components: the front and back end. The front end of the forecast system composes the web-based user interface to display the forecast maps. The back end of the system automatically collects weather forecasts in real time and computes surface hydrology output rasters using distributed watershed modeling. Web based tools like the prototype introduced in this study could fill a gap in the effort to minimize NPS pollution from agricultural lands.

Stream flow Responses to distributed inputs of soil and land use under a changing climate: SWAT model reconceptualization.

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Abstract

Abstract: In this research, The GIS (Geographic Information System) interface operational model, SWAT (soil and Water Assessment Tool) is coded and run for two separate cases; for the Natural Resource Conservation Service's Curve Number (CN) method of runoff estimation and for the topographic index concept of predicting and simulating the spatio-temporal dynamic locations of variable source area (VSA) dominant landscapes with topographic wetness index re-defined HRUs (Hydrologic Response Unit). Fifty years Land use/cover map and current soil map of the area is prepared with field soil survey and laboratory analysis for 32 soil sample pits, description augers, and 125 soil sample layers. Five land use classes and seven soil types are identified and coded to the model as primary space-time data sets to better physical conceptualization. The model is then calibrated and validated over the gauged lower reach of the study watershed, Batena and scenario series is developed for future land use and RCM (Regional Climate Model) for future climate to estimate rainfall run-off response in past and future time stamps. Model Stream flow predictions is better with re-conceptualization of SWAT to SWAT-VSA than SWAT-CN [over all Nash-Sutcliffe efficiencies (NSE) of 0.68 and 0.54, respectively]. The R^2 (coefficient of determination) for the catchment vary between 0.5 to 0.76 (VSA) during calibration and 0.55 to 0.73 during validation. To better understand the effect of spatially distributed inputs of soil and land use on the stream flow response of the area; the SWAT model was run with different scenarios; with FAO-UNESCO coarse grid resolution soil map and fine scale field surveyed soil map with all the model data inputs. The hydrograph fit between the estimated and observed flow series is also adequately represented.

Keywords

field soil survey, curve number, variable source area, swat model, stream flow, climate change, FAO coarse grid soil.

C-SWAT: An Easy Way to Save SWAT Computational Time by Consolidating Input Files

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Abstract

In the past two decades, the Soil and Water Assessment Tool (SWAT) has been broadly applied on topics related to general water resources and environmental engineering. By the aid of SWAT, scientifically credible evaluations can be provided to enhance the quality of relevant decision making procedure. Meanwhile, predictions of complex hydrologic and nutrient processes cannot be performed without requiring considerably large amount of input data. In SWAT applications, model inputs are stored in both subbasin and Hydrologic Responses Units (HRUs) levels. Computational time increases substantially along with the number of input files which could be a major concern on large-scale model implementations. To alleviate the computational burden caused by open/read/close input files, the Consolidated SWAT (C-SWAT) was developed to aggregate subbasin and HRU level information into 13 major files. A case study in the Little Washita River Basin (611 km²) was conducted in which 30% of computational runtime was reduced. The concept of C-SWAT is easy to transfer whereas future users can implement the same structure on other SWAT revisions.

Keywords

SWAT; Consolidated Inputs; Calibration; Parallel processing; Shuffled complex evolution

SWAT-GHG: a Mechanistic Greenhouse Gas Sub-model for SWAT

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Abstract

The impact of climate change and variability on nutrient cycling in agroecosystems, particularly the nitrogen cycle, is highly uncertain. Of particular interest is the impact of climate change on greenhouse gas (GHG) emissions from agroecosystems, particularly nitrous oxide (N₂O, a powerful GHG), which is controlled by several processes; namely soil temperature, soil moisture and soil carbon levels likely to be influenced by climate change. To determine the impact of climate change on these processes and to quantify N₂O emission at both the field and watershed scales, we develop a new more mechanistic GHG sub-model for SWAT. We synthesized previous research to develop the new sub-model to predict N₂O emission from agricultural watersheds. The new sub-model incorporates the ability to predict N₂O emissions (and improve N₂ prediction) by coupling the C and N cycles with soil moisture, pH and temperature in SWAT. The new sub-model involves a two-part addition: first, we developed a set of equations to model the total denitrification rate (N₂+ N₂O) by using reduction functions, and then, partitioned N₂ from N₂O by using a ratio method. The new N₂O sub-model was tested using data from the GRACEnet database in two locations; 1. Central Pennsylvania, and 2 Eastern Kentucky, by parameterizing the model with the plot level measurements of soil C, N, and pH as initial conditions. Results showed significant correlations between plot level measurements of N₂O flux and new SWAT model N₂O predictions. Furthermore, model results suggest that N₂O emissions are particularly sensitive to pH, soil temperature and soil moisture levels. This new GHG model can be used to assess the impacts of management practices such as tillage, drainage water management, nutrient management and soil amendments, in addition to the impact of climate change on N₂O emissions.

TopoSWAT: An ArcPy Toolbox to Improve the Spatial Representation of Soil Properties and Hydrology Using Topographically Derived Initialization Processes

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Abstract

Topography exerts critical controls on many hydrologic, geomorphologic, and environmental processes. Unfortunately many watershed modeling systems use topography only to define basin boundaries and stream channels and do not explicitly account for the topographic controls on processes such as soil genesis, soil moisture distribution, nutrient cycling and hydrological response. We develop and demonstrate an Arcpy toolbox for ArcSWAT that uses topography to spatially adjust soil morphological and soil hydrological attributes [soil texture, depth to the C-horizon, saturated conductivity, bulk density, porosity, and the field capacities at 33kpa (~ field capacity) and 1500kpa (~ wilting point) tensions]. We demonstrate the new initialization procedure and the ensuing improved model performance in three hydrologically dissimilar watersheds: one in the heavily glaciated northeast US, which exhibits classic variable source area (VSA) hydrologic responses; one in the Mid-Atlantic US, which has both VSA and Hortonian hydrology; and one in Texas, which displays classic Hortonian hydrology. The topographically derived initialization procedure exhibited significant correlations with distributed (field level) measurements of soil moisture, runoff generation and soil properties, and improved estimates of baseflow. This, in turn, resulted in improved predictions of field level contaminant transport, particularly for phosphorus. These results indicate that adjusting model parameters based on topography (using a priori distributions) can result in more accurate soil characterization and, in improve model performance at the field scale.

TauRkSWAT: An Operating System Independent SWAT Model Watershed Initialization Interface

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Abstract

GIS based interfaces, predominantly limited to Microsoft Windows platforms (e.g., ArcSWAT, MWSWAT and QSWAT), or more complex Unix/Linux based interfaces (e.g., GRASS), have been created to perform watershed initializations. None of these interfaces qualify as operating system independent and simple to install and use. Thus, there is growing demand for simpler (and open source) approaches to initialize SWAT, especially since watershed modeling projects are increasingly needed in scientific fields that have less geoprocessing experience. TauRkSWAT is a new watershed initialization interface project for the Soil and Water Assessment Tool (SWAT) model. TauRkSWAT is operating system independent, topographically informed, and is directly integrated into the powerful R (geo)statistical language, with single command line installation using the centralized CRAN repositories on any computer with R and GDAL programs installed. An added benefit of TauRkSWAT is that it is easily coupled with powerful R optimization routines (e.g. DE-Optim), statistical analysis libraries, and plotting functionality. TauRkSWAT integrates the benefits of the standard initialization software with the growing R community, thus further reducing the barriers to employing the SWAT model across an ever-growing number of scientific fields.

Twentieth century agricultural drainage creates more erosive rivers

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Abstract

Rivers in watersheds dominated by agriculture throughout the US are impaired by excess sediment, a significant portion of which comes from non-field, near-channel sources. Both land-use and climate have been implicated in altering river flows and thereby increasing stream-channel erosion and sediment loading. In the wetland-rich landscapes of the upper Mississippi basin, twentieth century crop conversions have lead to an intensification of artificial drainage, which is now a critical component of modern agriculture. At the same time, much of the region has experienced increased annual rainfall. Uncertainty in separating these drivers of streamflow fuels debate between agricultural and environmental interests on responsibility and solutions for excess riverine sediment. To disentangle the effects of climate and land-use we compared changes in precipitation, crop conversions, and extent of drained depressional area in 21 Minnesota watersheds over the past 70 years. Watersheds with large land-use changes had increases in seasonal and annual water yields of >50% since 1940. On average, changes in precipitation and crop evapotranspiration explained less than one-half of the increase, with the remainder highly correlated with artificial drainage and loss of depressional areas. Rivers with increased flow have experienced channel widening of 10-40% highlighting a source of sediment seldom addressed by agricultural best management practices.

Modeling Corn Crop Yields in High Water Table Conditions using SWAT Model

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Abstract

Adequate soil water is essential for plant growth and nutrient transport to plants, but excess soil water in root zone has been shown to affect crop yields. Subsurface tile drainage systems are typically implemented in poorly drained soils to remove excess water in the root zone and to improve trafficability and crop yield. Subsurface tile drains are a widespread practice in Midwest U.S., transforming poorly drained soils unsuitable for agricultural production into highly productive farm lands. High intensity, short duration rainfall events on poorly drained soils results in high water table conditions or temporary flooding even with subsurface tile drain system. This excess soil water for prolonged periods can result in reduced crop yields, especially for corn. This study focuses on modeling crop yields in the Midwestern poorly drained soils under high water table conditions using SWAT model. High intensity spring rainfall events in central IL in 2015 during early vegetative stage of crop can have severe impact on annual crop yield. Studies have identified excess soil water effects at various stages of corn growth on yields using a 30-day soil excess water (SEW₃₀) stress factor and developed regression equations for relative yield for corn. Current SWAT routines doesn't simulate negative effects of high water tables on crop yield; therefore, a methodology/algorithm needs to be developed for modeling crop growth under high water table conditions. This project focuses on a method to track soil water table, aeration stress, crop stages of development, and SEW₃₀ stress factors to model the overall crop yield in high water table conditions in SWAT model.

Keywords

crop yields. SWAT, water table, tile drain

Evaluating Water Quality Impact of Grassland Establishment

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Abstract

Grassland is a valuable natural resource with many environmental benefits such as reducing soil erosion, increasing carbon sequestration, providing wildlife habitat, and improving water quality. This study aims to investigate water quality implications of grassland establishment in a grass dominated watershed in South Dakota. The specific objectives are to (1) quantify the impacts of time variant grassland change on water quality; and (2) determine the optimum location of grassland establishment for water quality conservation in a watershed. The Soil and Water Assessment Tool (SWAT) will be used to evaluate “what is” scenarios for sediment, NO₃, and TP, as well as hydrology (e.g. runoff, ET, soil moisture, and water yield), in the Bad River watershed near Fort Pierre, South Dakota. The watershed has more than 80% of grassland and 14% of agricultural land use.

Keywords

land management, modeling, SWAT, South Dakota

SWAT Evaluation for Best Management Practices in Highland Agricultural Catchment of South Korea

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Abstract

This study is to evaluate the nonpoint source (NPS) pollution discharges from Haeon highland agricultural catchment (62.8 km²) using SWAT (Soil and Water Assessment Tool). The catchment is one of the several small catchments within Soyang watershed and now exports some of the world highest recorded levels for total nitrogen (T-N) and total phosphorus (T-P) to Soyang lake. The high levels of T-N provide for high potential algal the reduction ratio of the 30% reduction to the stream was higher than that of the 10% reduction to the stream. Growth, algal blooms and eutrophication in response to monsoon-rain-based pulses of T-P. The SWAT was calibrated (2009~2010) and validated (2011) using daily observed streamflow, sediment, T-N, and T-P data at three locations of the catchment. The average Nash and Sutcliffe model efficiency for streamflow was 0.69 and the determination coefficient for SS, T-N, and T-P were 0.73, 0.61, and 0.78 respectively. As the reduction ways for the NPS discharges from the watershed, especially the best management practices (BMPs) of fertilizer application control and filter strip installation were discussed for sustainable ecosystem service of highland agriculture.

Acknowledgement

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Keywords

SWAT, Highland agriculture, Haeon watershed, BMPs, Non-point Source Pollution

Modeling fate and transport of nutrients from onsite wastewater treatment system

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Abstract

Failing onsite wastewater treatment systems (OWTS) can potentially contribute excessive nutrient loadings to surface water. Due to the complex interaction of pollutants with hydro-geo-bio environment, it is difficult to estimate and/or monitor the impact at watershed scale. This study uses a modeling approach to quantify the impact locally, and scale the impact to the regional level for implications to stream water quality. A comprehensive watershed model, Soil and Water Assessment Tool (SWAT), capable of simulating OWTS biozone processes, was applied to the Lick Creek Watershed in North Carolina for the assessment and quantification of OWTS's nutrient contribution to Falls Lake. In this watershed, about 85 percent of the housing units uses OWTS. A modeling setup was constructed using topography, land use and septic system, soil characteristics and climate datasets. Model calibration validation is being conducted using field based data on flow and nutrients, and survey data on existing OWT systems. The result will assist local governments in decision making for nutrient management strategies.

Keywords

Septic systems, nutrient transport, SWAT modeling

Estimation of Regional Calibration of Hargreaves Equation for Actual Evapotranspiration using SWAT Simulated Results in the Mixed Forest Watershed

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Abstract

The Hargreaves equation provides reference evapotranspiration (ET_o) estimates when only air temperature data are available, although it requires previous local calibration for acceptable performance. This equation has been evaluated in South Korea using data from 74 meteorological stations, comparing daily estimates against those from the Penman Monteith (PM) equation, which was used as standard. This study is to evaluate evapotranspiration methods (PM, Hargreaves and regional calibration of Hargreaves) of SWAT model by comparing with the measured actual evapotranspiration data in Seolma-cheon watershed (8.48km²). By using 2007 daily streamflow at the watershed outlet, 3 months daily evapotranspiration data measured at mixed forest, the SWAT model was calibrated. The model was validated with 2008 streamflow, evapotranspiration and 4 years (2003-2006) streamflow. The average Nash–Sutcliffe model efficiency of streamflow during validation was 0.76 and the coefficient of determination (R²) of was 0.78. The regional calibration of Hargreaves (AHC) will be contributed for a better understanding of evapotranspiration an ungauged catchment in areas where meteorological information is scarce.

Acknowledgement

This research was supported by a Grant (11-TIC06) from Advanced Water Management Research Program funded by Ministry of Land, Infrastructure and Transport of Korean government.

Keywords

SWAT, Evapotranspiration, Hargreaves equation, Flux data

Simulation of surface runoff and soil erosion in small watersheds in Northern Ethiopia - application and verification of the SWAT model

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Abstract

Degradation of arable land is a major issue in the Ethiopian Highlands. Deforestation leads to ongoing soil erosion during the rainy season and thus the hydrology of a watershed changes as high erosion rates and dense gully networks cause a direct drainage of rain water usable for crop production. The application of hydrological models can provide a link between local watershed characteristics and the generation of runoff and sediment loss in the watershed. Furthermore, they enable the impact assessment of soil conservation measures on these processes. Objective of this study was to apply the SWAT model to two small agricultural used watersheds in Northern Ethiopia to assess the impact of soil conservation measures on surface runoff and soil erosion. The watersheds are two small sub-watersheds of the Gumara-Maksegnit watershed. They are located close to each other with an area of 31 and 41 ha, respectively. 80% of the area is steeper than 10%. In one watershed soil conservation measures (stone bunds and trenches) were implemented in 2011 whereas the other watershed is untreated. Mean annual precipitation is about 1200 mm from which 90% rains between June and September. Soil textures range from clay loam to clay. Land use of both watersheds is similar with appr. 70% of agricultural land and 30% of grassland and open shrubland. Main crops grown are sorghum, teff, faba bean, barley, wheat and chickpea.

Since 2011, an automatic weather station as well as weirs are installed in both watersheds to measure runoff. For each erosive event manual samples are taken in addition to a turbidity sensor to monitor sediment yield. Soil and land survey was carried out to derive a soil map and a digital elevation model. A site specific crop rotation was assumed.

The SWAT model calibration was performed with measured data from 2012. The results for runoff as well as sediment yield show acceptable to satisfying performance. The Nash-Sutcliffe efficiency for surface runoff is 0.54 for the untreated and 0.24 for the treated watershed.

Keywords

SWAT model, Ethiopia, soil erosion, surface runoff, watershed

Assessment of Forest Type and Future Climate Change Impacts on Streamflow in Small Catchment

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Abstract

This study is to evaluate the impact between agricultural activity and forest restoration of present agricultural areas on streamflow under the future climate change scenarios. The SWAT (Soil and Water Assessment Tool) was applied for a 1.17 km² typical small catchment of 83.3 % forest areas. Before evaluation, the SWAT was calibrated and validated using 2 years (2011-2012) and 1 year (2013) daily streamflow data at the catchment outlet. The average Nash and Sutcliffe model efficiency and the determination coefficient were 0.70 and 0.57 respectively. The annual streamflows by the forest type of coniferous, deciduous, and mixed forest for the whole watershed showed 13.31, 1.50, and 2.29 mm changes under the historical 30 years simulation (1976-2005). By applying the HadGEM3-RA RCP (Representative Concentration Pathway) climate change scenarios, the future streamflows for coniferous, deciduous, and mixed forest restoration showed 13.36, 3.01, and 0.11 mm changes in 2040s (2020-2059) RCP 4.5 scenario and 13.16, 4.04, and 0.18 mm changes in 2080s (2060-2099) RCP 8.5 scenario respectively.

Acknowledgements

This research was supported by a grant (14AWMP-B082564-01) from Advanced Water Management Research Program funded by Ministry of Land, Infrastructure and Transport of Korean government.

Keywords

SWAT, Small catchment, Forest type, Land use change, RCP, Climate Change

Comparison of Spatial Evapotranspiration between SEBAL and SWAT by Calibrating with the Eddy Flux measured ET

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Abstract

The purpose of this paper is to build a spatio-temporal evapotranspiration (ET) estimation model using Terra MODIS satellite image and by calibrating with the flux tower ET data from watershed. The fundamentals of spatial ET model, Surface Energy Balance Algorithm for Land (SEBAL) and Soil and Water Assessment Tool (SWAT) were adopted and modified to estimate the daily ET of Yongdam Dam watershed in South Korea. The daily Normalized Distribution Vegetation Index (NDVI), Albedo, and Land Surface Temperature (LST) from MODIS and the ground measured wind speed and solar radiation data were prepared for 2 years (2012-2013). The SEBAL was calibrated with the forest ET measured by Deokyusan flux tower in the study watershed. The SEBAL ET and SWAT ET were calibrated with coefficient of determination 0.52 and 0.42, respectively. During the period, Mean ET of SEBAL was 0.91 mm/day ranging from 0 to 5.88 mm/day while SWAT ET was 0.92 mm/day ranging from 0 to 3.60 mm/day. The SEBAL surface roughness factor affected the overestimation of ET. The spatial ET reflected the geographical characteristics showing the ET of lowland areas was higher than the highland ET.

Acknowledgement

This research was supported by a Grant (11-TIC06) from Advanced Water Management Research Program funded by Ministry of Land, Infrastructure and Transport of Korean government.

Keywords

Flux Tower, SEBAL, SWAT, Spatial Evapotranspiration, Terra MODIS

Impact of Drought on freshwater provisioning ecosystem services in the Upper Mississippi River Basin

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Abstract

Ecosystem services are the benefits that humans derive from ecosystems. Impacted by climate change and variability, and land use management, ecosystem services have been altered globally. Drought events can potentially have considerable impacts on ecosystem services. However, impacts of drought on ecosystem services are poorly understood. In this study we quantify freshwater provisioning ecosystem services and evaluate the effects of drought on freshwater provisioning ecosystem services in the Upper Mississippi River Basin (UMRB). Specifically, the annual freshwater provision (FWP) and freshwater provision index (FWPI) are quantified for each 4 digit HUC watershed by using an index-based method, based on the outputs of SWAT model in the UMRB. Then the past drought events in the basin are analyzed through calculating annual Standard Precipitation Index (SPI) for each 4 digit watershed using the historical rainfall data from 1950 to 2014. The annual SPI and FWP for main drought years are predicted under two precipitation changed scenarios and a baseline scenario in order to analyze the impact of drought on FWP. The FWP (FWPI) calculation results will help people initially understand about the current status of freshwater provisioning ecosystem services. Drought would be an important climate factor affecting the FWP. This study may provide information that can be used for making advanced land management decisions that can protect the freshwater ecosystem services in UMRB.

Keywords

Freshwater ecosystem services; Upper Mississippi River Basin; Drought; Standard Precipitation Index

Large scale flood inundation modeling by using SWAT and LISFLOOD-FP

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Abstract

Flood inundation maps play a major role in communicating the risk associated with floods, and during flood relief and rescue operations. Creating an accurate flood inundation maps requires the simulation of the flow condition by using a hydraulic model. Due to the limited availability of measured flow data from sparse streamflow gauges, it is not necessary to create a high quality flood inundation map for large areas without the use of a watershed hydrologic model in conjunction with a hydraulic model. A loosely coupled hydrologic-hydraulic modeling framework is developed in this study by using the SWAT hydrological model and the LISFLOOD-FP hydraulic model for flood modeling in the Ohio River Basin. First, SWAT model is calibrated by using selected USGS stations with long historical records, and then the calibrated model is used to generate streamflow time series for the entire stream network in the Ohio River Basin. Next, flood inundation map for the entire basin is generated by using only the USGS streamflow gauging network and then the SWAT generated streamflow. Results show that connecting SWAT with LISFLOOD-FP enables creation of good quality flood inundation maps for all streams including lower order streams without any streamflow gauge. The results are validated through comparison with FEMA generated flood inundation maps at selected locations in the basin.

Keywords

SWAT, LISFLOOD-FP, flood modeling

Quantification of blue, green and grey water in the Limpopo River Basin in Southern Africa using Earth Observation data and SWAT model

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Abstract

Adequate supplies of potable water is important to sustain agriculture, industry and domestic uses, particularly in semi-arid regions such as the Limpopo River Basin (LRB), Southern Africa where physical water scarcity is prominent. Effective planning and management of water resources in the region are hampered by scarcity of data due to limited hydro-meteorological stations thus limiting simulation modelling of water resources in the watershed. Earth Observation (EO) data will be ingested, in lieu of ground-based data, into the Soil and Water Assessment Tool (SWAT) to quantify availability and changes in blue, green and grey water footprints and drivers for agricultural and domestic uses in the LRB. Since reliable simulations are only possible if the hydrological model is soundly calibrated and tested, the LRB model will be spatially calibrated using evapotranspiration (ET) data from MODIS and soil moisture (SM) from ASMR-E data. Even though calibration with ET and SM is selected due to the lack of reliable streamflow data in the watershed, it is anticipated that this study will test accuracy of the spatial and multi-parameter calibration procedure. The outcomes of this study will not only be beneficial for operational and planning purposes of water resources in Botswana and the LRB, but will also continue to demonstrate the use of remotely sensed observations as viable alternative input data for hydrological modelling in ungauged and poorly gauged watersheds.

Keywords

Hydrologic modelling, data scarcity, water availability, Earth Observation data, semi-arid regions, Limpopo River Basin

To bias correct or not to bias correct? Is that really the question?

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Abstract

Using future climate data in Soil and Water Assessment Tool (SWAT) analyses is a common practice in the peer-reviewed literature. Integrating projected climate data directly into SWAT (and other watershed models) requires the modeler to make many decisions that could impact the model outputs. A majority of watershed modelers choose to bias correct their climate data. However, bias correcting data can alter the inherent physical relationships of the climate data itself, notwithstanding the great uncertainty associated with which bias correction method to choose. There still remains the question of whether or not bias correction is appropriate for incorporating projected climate data into SWAT. Outside of the decision to bias correct and what method to choose, many other decisions must be made by the SWAT modeler to evaluate the impact of future climate including: (1) which climate models to use (global, regional statically downscaled, regional dynamically downscaled), (2) using gridded climate model outputs or regridding climate model output to existing climate stations, (3) generating solar radiation, relative humidity, and wind speed using the built-in SWAT weather generator or using climate model outputs, and (4) increasing carbon dioxide concentrations in SWAT or not. Despite the number of studies that have used projected climate data in SWAT, few studies have demonstrated the uncertainty in the multiple choices made by modelers. The purpose of this work is to investigate the most common approaches that SWAT modelers use, and to develop best practices for integrating future climate data into SWAT.

Keywords

climate change, bias correction, SWAT, watershed modeling

Developing an in-stream water quality model for improved simulation of nutrient dynamics in SWAT

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Abstract

Soil and Water Assessment Tool (SWAT) is extensively used for simulating stream flow and nutrient transport in a catchment. In-stream water quality modelling is a critical component of the model for evaluating the fate of nutrients in streams and other water bodies. The SWAT incorporates a modified version of QUAL2E (steady-state water quality model) for simulating in-stream nutrient dynamics. Many published studies in literature report that water quality simulations in SWAT can have large deviations from observed data. This can be attributed majorly to lack of sufficient measured data, uncertainty in input data (concerning agricultural management practices and soil nutrient status) as well as inaccurate simulation of nutrient transport processes. Furthermore, studies have suggested a need for refining the QUAL2E algorithms in SWAT to better represent the biogeochemical processes occurring within the streams. This can improve the model predictions of downstream nutrient loads which is of a major concern in studies related to water quality simulations. Preliminary results of this study provides a comprehensive analysis of current in-stream nutrient transport algorithms in SWAT and brings forth its limitations along with suggestions for potential improvements. A case study on St. Joseph River watershed was carried out to substantiate the hypothesis that a simple external nutrient transport model can replace the current in-stream model in SWAT without yielding significant changes in nutrient loads at the watershed outlet. In future, it is proposed to develop a new in-stream water quality model with detailed process representation of nutrient transport in streams. Kielstau catchment located in Northern Germany will be used as study area for data collection and model development. Additionally, the study envisages to incorporate the proposed model in to SWAT for enhanced estimation of nutrient loads at multiple temporal and spatial scales.

Keywords

SWAT; In-stream nutrient transport; Water quality model

Evaluation of SWAT Soil Water Content Model Output and Sensitivity

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Abstract

Soil water content is of great interest in a range of ecohydrologic applications given its crucial role in a multitude of energetic, biogeochemical, climatic, and hydrologic processes and cycles. Because *in situ* observations of soil water content are limited by cost and spatial coverage, remotely sensed observations, model simulations, or some combination of both are often utilized in predictive analysis of ecohydrologic systems. It is therefore critical to capture the accuracy and practical limitations of such model or remotely sensed estimates. In particular, soil water dynamics in the Soil and Water Assessment Tool (SWAT) model have not been extensively evaluated with respect to accuracy nor interaction with other model variables and governing equations. Therefore, the objectives of this research seek to: 1) compare SWAT simulated soil water content to observed *in situ* and remotely sensed measurements and 2) evaluate SWAT model sensitivity to soil water content. Research was conducted at the Little River Experimental Watershed (LREW) near Tifton, Georgia, where 29 soil moisture stations with measurements at 3 depths are employed. A SWAT model was created, delineated based on several stream gauge locations within LREW. Remotely sensed soil moisture data was obtained from a multi-sensor, active/passive merged soil moisture data product from the European Space Agency's Essential Climate Variable (ECV) program. Simulated soil water content time series from the SWAT model was compared to both measured observations. To evaluate specific model response to dynamic soil water content, both global and local sensitivity was assessed for various SWAT hydrologic, water quality, and plant growth subroutines and outputs where results were examined relative to land use and soil classifications. It is expected that results from this analysis will aid in evaluating the accuracy of SWAT simulated water content as well as identifying possible areas for more targeted and rigorous model evaluation or improvement.

Keywords

sensitivity; soil water

Adopting an Energy Balance Snowmelt Model in Soil and Water Assessment Tool model (SWAT) for Application in Atlantic Canada

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Abstract

A simple energy balance snowmelt model was integrated with the Soil and Water Assessment Tool (SWAT) and was tested in a small agricultural watershed in Atlantic Canada. Rain-on-snow induced snowmelt was typical in maritime weather conditions and energy balance snowmelt model was expected to perform better than temperature index model due to its physical considerations. Simulation performances on flow rate at the outlet of the watershed were compared between energy balance model (EBM) and temperature index model (TIM) within SWAT. In default scenario where calibration parameters were not adjusted, EBM performed much better than TIM. R^2 , NS and bR^2 values of EBM were greater than those of TIM by average about 0.19, 0.25 and 0.15, respectively for two investigation periods (1992-2001 and 2002-2011). Thus, EBM was recommended in ungauged watersheds without information for snowmelt calibration. Furthermore, two models were calibrated in 1992-2001 period and validated in 2002-2011 period. Calibrated EBM still performed better than calibrated TIM in both periods. R^2 , NS and bR^2 values of EBM were greater than those of TIM by average about 0.06, 0.07 and 0.06, respectively for two periods. The improvement of snowmelt prediction accuracy by EBM over TIM was mainly cause by better simulation of rain-on-snow events. TIM severely underestimated snowmelt in pre-snowmelt seasons when snowmelt mainly derived by rain-on-snow events. Also, EBM performed better than or equivalent to TIM in snowmelt seasons when the main force of snowmelt was solar radiation. EBM improved R^2 by 0.12 and 0.15 compared with TIM in calibration and validation periods on snowmelt induced by rain-on-snow events, respectively. In addition, EBM performed better than TIM in capturing the snow depth variation induced by rain-on-snow events at a representative HRU between two models. The results of this study validated that the EBM performed better than TIM on snowmelt prediction especially for rain-on-snow conditions. EBM was a better option for SWAT application in maritime area such as Atlantic Canada, especially in ungauged watersheds and long-term simulation situations.

Modifying the Soil Temperature Module in SWAT for Application in Atlantic Canada: Module Development, Validation and Impacts on Watershed Modelling

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Abstract

Accurate estimates of soil temperature are of particular importance in describing many hydrological and biological processes. Soil-temperature predictions in the popular hydrological model, Soil and Water Assessment Tool (SWAT), are largely incorrect when applied to regions with significant snow cover in winter. In this study, a new physically-based formulation of soil temperature is developed as an alternative to the empirical soil-temperature module currently used in SWAT. The physically-based formulation simulates soil temperature in different soil layers as a result of energy transfer amongst the atmosphere, snow, and soil layers. With the new soil-temperature formulation, the only additional inputs for the modified SWAT are three new parameters, which need to be calibrated. Both the original and modified versions of SWAT are tested against field data collected from the Black Brook Watershed, a small watershed in Atlantic Canada. The results indicate that both versions of SWAT are able to provide acceptable predictions of temperature in different soil layers during the non-winter period of the year. However, the original SWAT severely underestimates soil temperatures in winter (within a range of -10 to -20°C), while the new version produces results that are more consistent with field-based temperatures (within a range of -2 to 2°C). The new physically-based formulation has greatly improved the ability of SWAT to simulate snow cover and insulation effects, which is essential to the application of SWAT in areas like Atlantic Canada, where the ground is covered by snow for an extended period of time in winter. Furthermore, water discharges, sediment and nutrient loadings estimated using the modified SWAT was compared against the original SWAT and field measurements for the same watershed. The results demonstrates that modified SWAT enhances the modelling accuracies on baseflow discharge, total discharge, sediment, NO₃-N and Sol-P loadings in the watershed because the new soil temperature module improves soil temperature simulation accuracy in winter. Moreover, this study also investigates the differences between the original and modified SWAT in determining water flow paths and nutrients fates in the watershed. Compared with the original SWAT, the modified SWAT predicts less surface runoff, lower soil moisture content but more percolation and lateral flow, especially for the winter period. Similarly, the modified SWAT predicts less nitrate loading with surface runoff while more nitrate loading with lateral flow and percolation in winter but less in other seasons.

Bioenergy grass production on marginal lands and hydrologic and water quality impacts in the Upper Mississippi River Basin (UMRB)

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Abstract

Approximately one fourth the Upper Mississippi River Basin (UMRB) is identified as marginal land, which could be an important land resource for producing perennial cellulosic bioenergy grasses. However, these areas could also potentially contribute disproportionate amounts of pollutants affecting surface and groundwater quality. In recent studies, water quality benefits from production of perennial grasses is generally acknowledged. However, suitability of marginal lands for biomass production and effects of establishment period on hydrology/water quality are not clear. This study provided a comprehensive evaluation of hydrologic and water quality impacts that potentially would be brought by producing switchgrass and *Miscanthus* on marginal land within the UMRB region. The establishment periods of perennial grasses were included in the model simulations and were considered separately from the established period when biomass is harvested. Marginal land suitability analysis indicate that only a small portion of the overall marginal land areas will be suitable for bioenergy crop production. The expected results of this study include: 1) higher water requirement by perennial grasses might reduce water availability in the UMRB region; 2) soil erosion and nutrient losses from the UMRB region were expected to be reduced greatly, except during the establishment period of perennial grasses and on marginal lands that have poor suitability for bioenergy crop growth.

SWAT model for policy analysis in drought hit California

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Abstract

With California entering its fourth year of a record-breaking drought, the region is experiencing the stress of water shortage like never before. Already a strained resource in the region, the current drought has forced the local policy makers and residents to adopt austere measures to deal with the latest lows in water availability. Decision making in such pressing scenarios can be quite overwhelming for the policy makers. This study aims to develop tools that incorporate hydrologic and social data to establish the feedback loops between the policy making and human behavioral processes with the objectives of social equity and sustainability. The prototype modeling framework is developed by using the San Joaquin River basin in California as the study area. To account for the physical effects of various policies, a SWAT model is developed that incorporates several reservoirs and inter and intra-basin water transfers of this highly managed watershed. This presentation will show how SWAT model can be effectively used for analyzing various policy measures for an integrated water resources management in a complex watershed.

Keywords

Policy analysis; Integrated water resources management

Designing Multifunctional Landscapes for Sustainable Bioenergy Feedstock in a Tile-Drained Agricultural Watershed

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Abstract

Biofuels are important alternatives for meeting our future energy needs. Successful bioenergy crop production requires maintaining environmental sustainability and minimum impacts on current net annual food, feed, and fiber production. Therefore placement of energy crops on strategically selected subfield areas in an agricultural landscape has the potential to increase the environmental and economic sustainability if location and choice of the crops result in improved environmental benefits and minimal disruption of current food production. This study identified subfield marginal areas in a tile-drained agricultural watershed using soil-based environmental and economic sustainability criteria and demonstrated the utility of remote sensing for determining under-productive areas. We used an expanded definition of marginal soils to include their crop yield potential and the potential for environmental impact when put into agricultural production. In the test watershed, 2.74% of soils had low crop productivity index (CPI areas) while 22.2% had at least two marginalities or were susceptible to nitrate leaching, the major surface water nutrient impairment in the watershed (marginal areas). A calibrated Soil and Water Assessment Tool (SWAT) was used to forecast the impact of growing switchgrass (*Panicum virgatum*), willow (*Salix spp.*), and big bluestem (*Andropogon gerardi*) in these subfield CPI and marginal areas, on annual corn and soybean yields, NO₃-N and sediment exports, and water yield. Conversion of marginal areas to switchgrass on average increased total annual crop yields (grain + biomass) from 187,893 to 199,416 metric tons with the least impact on water yield (3.8% reduction) and the highest reduction in NO₃-N (24%) and sediment (57%) export. On average, conversion to willow showed the highest reduction in annual water yield (19%) with comparable but significantly different reductions in NO₃-N export (23%) and similar sediment export (54%) to switchgrass.

Improve simulation of annual crop sensitivity to climate variability in the Eastern Corn Belt

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Abstract

Soil moisture has a complicated relationship with corn growth. Both when limited and oversupplied, water brings stresses to corn development. When using modelling methodologies to evaluate crop sensitivities to climate variability, soil moisture needs to be well represented. However, it is difficult to execute moisture calibration at the watershed level due to both data scarcity and scale issues. In this study, we evaluate an approach to ensure better model moisture simulation without relying on soil moisture calibration. The main idea is to regulate annual crop yield, seasonal crop development and daily surface water budget simultaneously for the St. Joseph River watershed in the Eastern Corn Belt. Hydrological parameters are first calibrated to address the near surface water balance. Daily streamflow data from three U.S. Geological Survey (USGS) stations inside the watershed will be compared with flow simulations. Then a multi-objective calibration approach is applied on crop biophysical and stress parameters to ensure the successful representation of annual yield, seasonal crop development and daily streamflow. A normalized regional Leaf Area Index (LAI) curve has been developed for the study domain using available Landsat TM 5 images for multiple years (2000-2010). The simulated model LAI curve is then compared with observed data from Landsat for both wet and dry years to identify sensitivities to climate extremes. National Agricultural Statistics Service (NASS) county level observed yield data is used to examine model performance in predicting annual yield and interannual yield variability. Site recorded soil moisture data will finally be compared with simulated soil water content to evaluate our approach in representing moisture without direct calibration.

Keywords

climate variability, crop yield, seasonal crop development

Climate model biases and statistical downscaling for application in hydrologic model

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Abstract

Climate change impact studies use global climate model (GCM) simulations to define future temperature and precipitation. The best available bias-corrected GCM output was obtained from Coupled Model Intercomparison Project phase 5 (CMIP5). CMIP5 data (temperature and precipitation) are available in daily downscaled datasets using bias-correction and constructed analogs at a spatial resolution of (~12 km by 12 km). Downscaling techniques are used to address the scale mismatch between CMIP5 output and finer scale details required for hydrologic modeling. The method used to correct the bias in CMIP5 data compared to observed datasets can be a source of uncertainty in impact assessment studies. The objective of this study was to evaluate two statistical downscaling methods to minimize uncertainty when modeling future climate scenarios in hydrological models. The downscaling methods used include delta and quantile mapping using observed weather datasets from the Goodwater Creek Experimental Watershed (73 km²), located in Audrain and northeastern Boone counties, Missouri. Results indicate that there was little bias between data over the observed record and the CMIP5 data in average annual precipitation using delta method. However, extremes were under-represented for almost all time steps (daily max, monthly max, yearly max, and yearly min). Quantile mapping was able to reproduce the extremes and correct the bias in most cases for the precipitation. Work on downscaling the temperature using quantile mapping is in progress and results will be included in the presentation. These downscaled data will be used to drive SWAT simulations for the study watershed to evaluate the potential for changes in hydrology given future climate scenarios.

Keywords

Bias, CMIP5, statistical downscaling, watershed

Evaluation of climate and land use changes on hydrologic processes in the Salt River Basin, Missouri, United States.

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Abstract

The impact of climate and land use changes on hydrologic processes at the watershed scale is needed by land managers and policy makers to properly assess potential adaptation strategies. While numerous studies have been conducted on hydrologic processes in the Midwest, only a few have analyzed the linkages between climate and land use changes. The objective of this study is to assess the combined impacts of climate and land use changes on hydrologic processes of the Salt River Basin (SRB). This basin, located in Northeast Missouri, is a direct tributary to the Mississippi River. Total drainage area is 6,417 km² at the outlet of Mark Twain Lake. The Soil and Water Assessment Tool (SWAT) was used to characterize hydrology in the SRB under varying future climate and land use scenarios. The watershed's hydrologic processes were simulated using streamflow data at two USGS stations from 1970-2060, with model calibration from 1970-1999 and validation from 2000-2013. Future climate data from 2014-2060 were obtained from Downscaled CMIP5 Climate Projections. Two representative concentration pathways (RCPs), RCP 8.5 and 4.5, were considered. Statistical downscaling methods, including delta method and quantile mapping, were used to further downscale these data to the climate station level. Four land use scenarios that project increases and decrease of agricultural land were created. Combinations of land use and climate changes over a range of conditions were examined to indicate possible outcomes useful for local and national agency application.

Quantifying Flood Risk and Sensitivity to Climate Change in the Huron River Watershed Using SWAT

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Abstract

The Huron River Watershed is located in southeastern Michigan and is approximately 2,300 km² in size, containing about 500,000 residents in 65 municipalities. Pockets of urban and developed lands occupy one-third of the land cover and may have the potential for greater risk of flooding, due to impervious surfaces and population density. It is thus of great interest to identify the areas that may have high flood risk and greater sensitivity to future climate change. In this study, we calibrated a SWAT model to flow discharge data under historical climate conditions. Then we quantified that spatial distribution of flooding risk using two indices: flood hazard index, the probability when stream discharge is larger than bankfull discharge, and flood regulation index, a function of the duration of flood events, average magnitude of flood events, and number of flood events per year with user-defined weights. We also tested different temperature and precipitation conditions under future climate change scenarios. By comparing the outputs, we identified the subbasins with elevated risk and greater sensitivity to climate change. Some of these subbasins coincide with urbanized areas. The findings contribute to a larger effort to evaluate climate change-induced risk and the potential impacts on residents in the Huron River Watershed.

Keywords

Flooding hazard, Climate change, SWAT

Closing the prediction gap between agricultural nutrient losses and riparian zone ecology

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Abstract

The ecological health of the Chesapeake Bay is an ongoing concern and, as the more obvious and direct contributors are mitigated, focus is moving upstream to the agricultural headwaters of the basin. TMDLs and Watershed Implementation Plans (WIPs) have been developed by all states in the basin to control nonpoint source pollution by applying nutrient- and sediment-reducing Best Management Practices. However, there is minimal work connecting nutrient losses from agricultural fields to biological stream quality. Except in the case of extreme events, the most direct connection between nutrients and stream health is the health concern to infants from stream nitrogen levels greater than 10ppm and the increased risk of algal blooms under high levels of phosphorus. This study compares TopoSWAT-modeled and monitored nutrient data with biological index scores and trends. Correlations among various sites and ranges of land management will be analyzed to improve our understanding of the connection between agricultural nutrient losses and the ecological health of the receiving riparian zone.

Keywords

agricultural management, TMDL, environmental impact, benthic macroinvertebrates

Estimating Nitrate Transport in Surface-Subsurface Hydrologic Systems by the linked SWAT-MODFLOW-RT3D Model

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Abstract

Integrated modeling of surface and subsurface hydrology and solute transport is a crucial tool for assessing the impact of land management practices on water yields and agricultural chemical fate and transport in watershed systems. Of the existing watershed models, the Soil Water and Assessment Tool (SWAT) has been used extensively for analysis of water resources and remediation of nutrient pollution in watersheds of varying scale and complexity. However, application of the model is limited in watersheds wherein streamflow is strongly affected by groundwater discharge, due to the simplistic implementation of groundwater flow and solute processes. In this study, the recently developed SWAT-MODFLOW model is linked with the groundwater solute reactive transport model RT3D (Reactive Transport in 3 Dimensions) to provide a model that simulates not only land surface and in-stream hydrologic, biological, and nutrient processes, but also flow and reactive solute transport in the aquifer and nutrient mass transfer between groundwater and surface water. The subroutines used to transfer data between SWAT Hydrologic Response Units (HRUs) and the finite difference grid cells employed by MODFLOW and RT3D are presented, as well as the pre-processing code routines required to formulate this linkage. An application of the SWAT-MODFLOW-RT3D model to the North Fork of the Sprague River Watershed (759 km²) in southern Oregon, United States, is presented, with both hydrologic (e.g., stream and groundwater discharge, and water table comparison) and nutrient (e.g., in-stream and groundwater nitrate concentrations, in-stream nitrate loading) system-response variables tested against measured data. Results show that in-stream nitrate loadings simulated by SWAT-MODFLOW-RT3D matched well with the observed field data as compared to the SWAT simulation. In addition, results show that nitrate mass is mainly concentrated along the river corridor in the western region of the Basin.

Keywords

SWAT-MODFLOW-RT3D model; Nitrate transport

Improved simulation of edaphic and manure phosphorus loss in SWAT and TopoSWAT

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Abstract

Watershed models such as the Soil Water Assessment Tool (SWAT) and (APEX) are widely used to assess the consequences of agricultural nutrient management practices on soluble and particulate phosphorus (P) loss in runoff. Soil P cycling routines used in SWAT2012, however, do not simulate the short-term effects of applying a concentrated source of soluble P, such as a manure, to the soil surface where it is most vulnerable to runoff. We added a new set of soil P routines to SWAT2012 to simulate surface applied manure at field and subwatershed scales within watersheds in Pennsylvania and Texas. We corroborated the new P version of SWAT against the standard SWAT P routine. Corroborative systems involved standard SWAT, a topographically driven version of SWAT (TopoSWAT), and five and 12 years of measured data under field-specific, historical management information in Pennsylvania and Texas, respectively. Short-term “wash off” processes resulting from precipitation immediately following surface application of manures were captured with the new P routine whereas the standard routines resulted in losses regardless of manure application. The new routines improved sensitivity to key factors in nutrient management (i.e., timing, rate, method, and form of P application). Only the new P routines indicate decreases in soluble P losses for manure applications at one, five and 10 days, respectively, before a storm event. Unlike with standard P routines, the new P routines exhibit greater variation among proportions of organic, particulate and soluble P corresponding to spreading method. Results suggest similar revisions to other agroecosystem watershed models would be appropriate.

Evaluation of the two-stage ditch as a best management practice

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Abstract

Artificial drainage has long been an important component of agriculture in the poorly-drained regions of the US Corn Belt. Continued increases in drainage intensity funnel more water into existing drainage ditches, resulting in higher flood stages, more erosive water velocities and decreased time for in-channel nutrient processing. The two-stage ditch is a type of in-stream restoration that involves modification of a trapezoidal drainage ditch to resemble more the features of a natural stream. The idea is to create or simulate extended benches on both sides of the ditch that would develop naturally over a period of time in a stream because of geomorphological processes. These in-channel flood plains provide a greater flow area during high flow events and offer the potential to reduce sediment load and extend the interaction time between water and vegetation on the benches, allowing larger uptake of nutrients and increasing the denitrification rates in the bench soil. The Soil and Water Assessment Tool (SWAT) hydrologic model has recently been modified to represent the two-stage ditch as a conservation practice. Processes that are represented in the model include: velocity reductions due to the change in channel geometry, particle settling, plant nutrient uptake and denitrification on the benches of the two-stage ditch. The model is evaluated using data collected from a two-stage ditch constructed at the Throckmorton Purdue Agricultural Center (TPAC) near Lafayette, Indiana in September 2012. It drains an area of approximately 2.7 km² of farmland used for corn and soybean production. Simulation results for 30 years of weather data indicated the impact of the two-stage ditch on reducing peak flow rates, flood stage and nutrient loads. For this 30 year period, 1985 – 2014, the results showed reductions of up to 40% of peak flow velocities, 35% reduction per km of two-stage ditch, of sediment basin output, 10 – 80% reduction in total phosphorus output and 0 – 15% reduction in total nitrogen.

Keywords

two-stage ditch, SWAT, routing nutrients

Assessing the Impact of Alternative Management Strategies in a Dairy-dominated Agricultural Watershed Vulnerable to High Sediment and P Runoff

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Abstract

Plum Creek, Wrightstown, WI (90.1 km²) is a predominately agricultural watershed which contributes substantial loads of phosphorus (P) and sediment to the Lower Fox River. The average annual yield of phosphorus between 2011 and 2014 was 2.37 kg/ha at a USGS station located on the main stem of Plum with a drainage area of 52.5 km². Approximately 90% of the sediment, and 75% of phosphorus annual load occurs during less than 14 days per year. Understanding the impact of various land management activities in relation to highly event driven loads is a critical aspect to reducing P and sediment loading to Plum Creek and meeting water quality goals for the Lower Fox River and Lower Green Bay. In this study, we used the Soil Water Assessment Tool (SWAT) to assess water quality and hydrologic response under alternative land use/management conditions. Water quality data collected at the main stem monitoring station in Water Years 2011 and 2012 were used to calibrate the model. WY 2013 data from the Main Branch was used to validate the SWAT model.

This paper focuses on BMP modeling methods of the study. Dairy grazing, cover cropping, increased conservation tillage, and reduced soil test P were chosen as target BMP practices. Suites of these BMPs were also modeled for a combination effect. It was found that reducing soil test P alone could reduce P runoff by about 16% from the watershed. Phosphorus and sediment reductions from conservation tillage ranged from 23 - 39% and 26 - 50%, for managed grazing 20 - 47% and 22 - 55%, and cover cropping 18 - 25% and 20 - 27%, respectively. These results are encouraging considering that other modeling projects for the Bay of Green Bay indicate that at least a 50% total load reduction will be needed to meet TMDL requirements. These practices impact roughly 14% of the load to Green Bay, consequently effective and efficient BMPs will be required to improve water quality.

Keywords

SWAT model, water quality, land management, BMP, sediment, phosphorus

Multisite Sensitivity Analysis and Calibration of a SWAT Model on a Selected Urban Watershed in Metropolitan Atlanta, Georgia

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Abstract

The objective was to stress the importance of simultaneous multisite application in watershed calibration and sensitivity analysis to obtain more representative parameter values in comparison with single site calibration. A 44 km² watershed located in metropolitan Atlanta, Georgia and a 2 km² sub-basin within this watershed with mainly urban land use and septic systems were selected to simulate flow in streams using the Soil and Water Assessment Tool (SWAT). The precipitation and temperature data was obtained through the PRISM (Parameter-elevation Regression on Independent Slopes Model) climate and weather system. The model was run from 2008 to 2014 with 4 years warm up and a daily time step. Stream discharge for the watershed was obtained from USGS gaged station at the outlet of this watershed, and for the sub-basin was gathered from an ungaged stream which was equipped with an automated gage recorder from 2012 to 2014. For model calibration and sensitivity analysis software, SWAT-CUP SUFI-2 and manual calibration were used and Nash Sutcliffe Efficiency (NSE) was chosen as an objective function. Calibrated model for the watershed stream flow showed the daily NSE was 0.74 with a p-factor of 0.66. The model didn't show a good NSE for the sub-basin. More detailed results of this study will be presented and discussed.

Is site-specific APEX calibration necessary for field scale BMP assessment?

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Abstract

The possibility of extending parameter sets obtained at one site to sites with similar characteristics is appealing. This study was undertaken to test model performance and compare the effectiveness of best management practices (BMPs) using three parameter sets obtained from three watersheds when applied to a fourth one. The first watershed was a no-till corn-soybean field in northeast Missouri, during 1993-1997 (parameterization 1). The second one was the same watershed during 1998-2008 after the establishment of agro-forestry buffers (parameterization 2). The third watershed was a corn-soybean field, 90-km from the Novelty site and with the same claypan soils (parameterization 3). An adjoining field with terraces, a grass waterway, and winter cover-crops, and monitored during 2011-2013 was used as the validation watershed. Model performance for runoff was good with all three parameterizations; coefficient of variation (r^2): 0.7 to 0.8, Nash-Sutcliffe Coefficient (NSC): 0.3 to 0.6, and percent bias (Pbias): -20 to 6%. Model performance for sediment was good only with parameterizations 1 and 3 (r^2 : ~0.5, NSC: 0.4 to 0.5 and Pbias: 23 to 53%). For total phosphorus (TP), model performance was good only with parameterization 3 (r^2 : 0.9, NSC: 0.5 and Pbias: 66 %). Thirty-year average annual predictions varied between the three parameterizations by 1-51%. However, the relative reductions in runoff, sediment and TP remained within 12%. All parameterizations predicted terraces were the most effective for sediment and TP, and cover crops for runoff. All three parameterizations showed good robustness in quantifying the relative effectiveness of BMPs.

Future EPIC to SWAT Linkages

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Abstract

Over the last 5 plus years Dr. Benson and the UNC Institute for the Environment have been working for EPA to build a system of EPIC data sets to make simulations for up to 21 crops for each 12 km grid in the U.S., Southern Canada and Northern Mexico. This has resulted in approximately 250,000 sets of EPIC data sets. Current analysis underway for biofuel assessment has resulted in about 500,000 EPIC sets of files to look at crops on original representative soils and on soils previously in other crops. Future global warming assessment will result in more EPIC data sets. There is a potential linkage between SWAT and/or APEX and these EPIC data sets and daily output files. This presentation describes the system used to generate the EPIC files and shows some current application results. The potential for cooperative efforts with SWAT and APEX modelers is considerable.

Soft-Data Considerations in Modeling Watershed-Scale Phosphorus Loads in the St. Croix Basin, Minnesota and Wisconsin, USA

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Abstract

Lake St. Croix is a 40-km long riverine lake that lies at the terminus of its 20,000-km² watershed, which straddles the border between Minnesota and Wisconsin. The lake is impaired by cultural eutrophication driven by excess phosphorus (P) loads coming largely from agricultural nonpoint sources. To better understand nonpoint P source and transport factors, we constructed a Soil and Water Assessment Tool (SWAT) model of the St. Croix basin.

Given 18 years of observed monthly P loads from where the St. Croix River enters the lake (our hard-data calibration target), we could calibrate the model with any number of non-unique parameter sets. To constrain the calibration, we considered soft-data targets from the literature. To start, we adjusted soil chemistry parameters to produce average total phosphorus yields of about 1-2 kg/ha/yr from chisel-plowed row crops, which provided a benchmark for parameterizing other land uses. Then runoff was routed through lowlands (ponds and wetlands in SWAT), which removed about 10% of the P load. Based on hydraulic residence time and mean depth, lakes on the channel network were parameterized to trap about 25% of incoming P and for Lake St. Croix to trap about 30% of incoming P, as determined from both monitoring and sediment studies. Finally, in-channel water-quality parameters were adjusted in SWAT to smooth the seasonal distribution of P loads entering Lake St. Croix, reducing peaks during high-runoff months and increasing loads during low-runoff months, such that the total annual P loads were approximately unchanged.

Keywords

agriculture; nonpoint source pollution; nutrients; phosphorus; phosphorus retention; soft data; surface water hydrology; watershed model

Using SWAT to Understand Stream Phosphorus Concentrations and the Importance of External Inputs and Internal Reactions

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Abstract

Managing stream phosphorus concentrations will require linking landscape nutrient transfer and in-stream reaction to the temporal variations in stream concentrations. The large temporal variability in stream phosphorus concentrations reflects the timing and magnitude of external inputs along with in-stream routing, chemical processes and biotic reactions. In this study, we incorporated SWAT in a combined landscape and stream model to help assess the sensitivity of stream phosphorus concentrations to these factors under different hydrologic conditions. Our model uses SWAT with an in-stream reaction model OTIS. The SWAT modeling used a sub-hourly time-step and the Green-Ampt infiltration model to estimate runoff and nutrient transfer. The 1-D OTIS model incorporated sorption, reaction and sediment release of phosphorus. The linked model was used to contrast the impact of external inputs and reaction on the temporal variability of stream phosphorus concentrations in watersheds with different hydrologic characteristics. Our results show that detailed characterization of growing season reactions and hydrologic characteristics is necessary to simulate concentrations in low baseflow streams. This study improves our ability to generalize the variations in stream phosphorus concentrations and understand the role that management can have on changing those concentrations.

Keywords

Stream phosphorus concentrations, nutrient transfer, in-stream nutrient reactions

Assessing SWAT Model Capability in predicting the Areas Contributing Flow in an Agricultural Watershed

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Abstract

This study is being conducted to assess the capability of SWAT model to identify the areas which contributing to the flow in a watershed. SWAT model was used to evaluate the hydrology at Gully Creek Watershed located in Ontario. Daily streamflow data from 12 July 2010, to 30 September 2011, were used for calibration, and the data from 1 October 2011 to 28 March 2012, were used to validate the model performance. In addition to the daily streamflow data, the flow/no flow observations were available for 18 different monitoring stations at 9 different events (162 events in total; 65 flow observed and 97 no flow observed). The calibrated model was also used to simulate the streamflow at the monitoring stations across the watershed. The simulation results at these stations were compared to the observed flow/no flow data. The results showed that 100% (65/65) of the observed flow events were predicted by the model properly, while only 50% (49/97) of the observed no flow events were predicted by the model. The impact of number of subbasins on capability of the model to predict the flow/no flow data are being studied and the results will be presented.

Keywords

Hydrological modeling; SWAT; DRAINMOD; SWATDRAIN; Watershed scale.

Modeling Sediment and Nutrient Loads Input to the Chesapeake Bay and Effects of Conservation Practices on Water Quality

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Abstract

Excess sediment and nutrients discharged into the Chesapeake Bay from agricultural land, urbanized area, forests and municipal and industrial discharges in the watershed have caused eutrophication in the Bay and in the surrounding water bodies. Determining the magnitude of sediment and nutrient loads entering Chesapeake Bay, and evaluating the effects of cropland conservation practices on water quality would be useful for planning and prioritizing management efforts. The field-scale model Agricultural Policy Environmental Extender (APEX) was used to simulate the conservation practices on cropland and Conservation Reserve Program land and assess the edge of field water quality benefits. Predicted flow and loads from APEX were input to the watershed scale model, Soil and Water Assessment Tool (SWAT). SWAT was used to simulate the watershed processes and estimate the instream water quality benefits. SWAT model was calibrated for streamflow, sediment and nutrients at multiple sites in the CB watershed. These models were then used to (1) estimate the sediment and nutrients entering the Chesapeake Bay, and (2) estimate the effects of various cropland conservation practice strategies on water quality in the Chesapeake Bay. Model predictions indicated that 6.9 million tonnes of sediment, 140,476 metric tonnes of nitrogen and 6,845 metric tonnes of phosphorus loads were entering the Bay as per baseline conservation condition in 2006-06. Currently established practices on cropland were predicted to reduce the sediment, nitrogen and phosphorus losses from edge of field within each 8-digit watersheds by 54%, 27% and 58%, respectively. These practices were predicted to reduce the sediment, nitrogen and phosphorus loads entering the Chesapeake Bay by 16%, 12%, and 16%, respectively. Additional conservation treatment can help to further reduce the loads to the Bay and move towards the proposed sediment and nutrient targets.

Keywords

CEAP, SWAT, APEX, Conservation Practices, Chesapeake Bay, Sediment, Nitrogen, Phosphorus

Assessing sensitivity of UMRB agriculture and water resources to past and current drought

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Abstract

The Midwest is critically important for the US economy for its agricultural production. Although, some studies imply that the climate change may enhance the certain crop yields, climate variability may have considerable impacts on crop production and ecohydrology. For example, heavy precipitation events with increased frequency may damage crops, and increase soil erosion and pollutant losses. In drought-affected areas land degradation, water stress and crop damage and failure may increase. In this study, we focused in the Upper Mississippi River Basin (UMRB) located in the US Midwest. The major objective of this study was to assess sensitivity of simulated crop yield, runoff, and water quality to drought for historic and current climate conditions. Time series of water quality, streamflow and crop yields were investigated. Water quality during past drought conditions were compared to water quality during reference periods, representing normal hydrological conditions. We calibrated and validated simulated monthly flow, sediment, total N, total P, organic N loads and concentrations. The initial results indicated that the SWAT model successfully simulated the annual crop yield and water quality, streamflow and the trends for current climate (1970-2010). We will discuss the impacts of drought on crop production and ecohydrology in detail in this presentation.

Keywords

UMRB, drought, crop, water quality, SWAT

Impact of Tile Drainage on Sediment Losses in an Agricultural Watershed using SWATDRAIN

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Abstract

The DRAINMOD model was recently incorporated into Soil and Water Assessment Tool (SWAT) model, and the resulting model, called SWATDRAIN, can simulate both surface and subsurface hydrology of tile-drained watersheds very well. In this study, SWATDRAIN was evaluated using measured streamflow and sediment loads data in a partially tile-drained watershed in Ontario, Canada. Simulations were carried out over a 10-year period, from 1975 to 1985; the 1975-1980 data were used for model calibration and the 1981-1985 data were used for validation. Along with hydrographs, the Nash-Sutcliffe efficiency (NSE), percent bias (PBIAS) and R² statistics were used in evaluating the accuracy of SWATDRAIN streamflow and sediment predictions in light of measured values. During both calibration and validation periods, SWATDRAIN simulated the hydrologic response and sediment loads at the outlet of the watershed better than SWAT. Our results also show that while the average annual simulated streamflow, with no tile drainage, was not much different than the streamflow with tile drainage, the sediment load, however, increased significantly with no tile drainage, which might be due to the increase in surface runoff.

Keywords

Hydrological modeling, SWAT, DRAINMOD, SWATDRAIN, Sediment losses.

Comparison of the tile drainage routine performance in SWAT 2009 and 2012 in the Little Vermillion River Watershed

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Abstract

Subsurface drainage systems are common practices in agricultural watersheds in the Midwestern U.S. Subsurface drainage systems enable the Midwest area to become highly productive agricultural lands, but also create environmental problems, like nitrate-N contamination and pesticide transport. Soil and Water Assessment Tool (SWAT) has been widely used to model watersheds with tile drainage. However, SWAT2009 revision 528 and SWAT2012 revision 645 provide different tile drainage routines, and the appropriate routine for simulating hydrologic processes and nutrient losses in Little Vermillion River Watershed (LVRW) and similar watersheds was unclear. Moreover, SWAT2012 revision 645 improved the curve number calculation method based on soil moisture, which has not been fully tested. This study used long-term (1991-2003) monitoring field site and river station data from LVRW to evaluate performance of tile drainage routines in SWAT2009 revision 528 (the old routine) and SWAT2012 revision 645 (the new routine). Uncalibrated simulated daily, monthly and yearly tile flow, surface flow, nitrate-N in tile and surface flow, sediment and annual corn and soybean yield results from SWAT with the old and new tile drainage routines were compared with observed values. Statistical analysis such as percent error (Pbias), coefficient of determination (R^2), Nash-Sutcliffe efficiency (NSE), the modified NSE and Kling-Gupta efficiency (KGE) were calculated. The results showed that both routines provided reasonable results but not satisfactory uncalibrated flow and nitrate loss results and the new routine had poorer uncalibrated results. Parameters describing tile and surface flow, groundwater, evapotranspiration, and nutrient and sediment routine processes will be selected for sensitivity and uncertainty analysis to determine values or potential ranges for parameters and model calibration. SWAT with both routines will be calibrated and validated at field sites and river stations. Pbias, R^2 , NSE, the modified NSE and KGE will be used for model validation. The results can determine which routine provides a better model fit and allow selection of the most appropriate tile drainage routine suitable for modeling LVRW and similar watersheds.

Keywords

subsurface flow, surface flow, sediment load, nitrate losses, crop yields, SWAT, tile drainage routine, curve number

Multi-objective calibration approach for SWAT by using spatially distributed remotely sensed/in-situ soil moisture data

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Abstract

The objective of this study is to evaluate the potential of using spatially distributed surface and root zone soil moisture estimates in calibration of Soil and Water Assessment Tool (SWAT) towards improving its hydrologic predictability with reduced equifinality. The proposed calibration approach is performed using remotely sensed Advanced Microwave Scanning Radiometer - Earth Observing System (AMSR-E) surface soil moisture (~ 1 cm top soil) estimates at each sub-basin level in conjunction with observed streamflow data at the watershed's outlet. Although application of remote sensing data in calibration improves surface soil moisture simulation, other hydrologic components such as streamflow, evapotranspiration (ET) and deeper layer moisture content in SWAT remain less affected. An extension of this approach to also include root zone soil moisture estimates from limited field sensor data showed considerable improvement in simulating streamflow and the root zone soil moisture. Difference in relative sensitivity of parameters and reduced extent of uncertainty are also evident from the proposed method, especially for parameters related to the subsurface hydrologic processes. While the results from this study show that root zone soil moisture can play a major role in SWAT calibration, more studies including various soil moisture data products are necessary to validate the proposed approach.

Keywords

AMSR-E, calibration, multi-objective, remote sensing, root zone, soil moisture, SWAT, uncertainty

Hydrologic Similarity Analysis by Unsupervised Classification of watershed's Soft Data Received from the SWAT Model.

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Abstract

The use of Soil and Water Assessment Tool (SWAT) to effectively model the watershed is constrained by the availability of data for parameter calibration and validation. To model ungauged watersheds, the parameters could be transferred from hydrologically similar gauged watersheds. This study aims at quantifying hydrologic similarity between watersheds. Most of the reported studies use either the watershed response or its morphology to test the hydrological similarity, and, in some cases, the geographically close watersheds are considered to be hydrologically similar. In this study, the remote sensed data of the land use, soil characteristics and the Digital Elevation Model (DEM) of the watershed along with measured weather data can be used to perform an unsupervised classification of the watersheds. Some of these data have quantitative values and some of them are classes. All these data represents the hydrologic process happening in the basin and, on top of that, it has some redundant information. Hence, it is planned to feed these data into the SWAT model and the get the flow outputs, then the flow outputs will be used to classify the basin. This method, in a way, would discard redundant information and use the correct weightage for the remotely sensed and weather data for classifying the basin. The Fuzzy- C-Means analysis will be used for the unsupervised classification. The validation of this method will be done by cross-comparing with other methods of hydrologic similarity and also analyzing the performance of the transferred parameters in the ungauged watersheds.

Keywords

Predictions in ungauged basins, Hydrologic Similarity, SWAT

Recent Technological Advancement and Sustainable Solutions for Flood Issues in North Bihar

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Abstract

Bihar is geographically situated in such a way that it has many natural perennial rivers coming from the Himalayas through Nepal and Tibet. These rivers are mostly alluvial & therefore, unstable. The constant & unpredictable shifting of river courses (due to heavy silt load) carries every year untold loss and misery to millions. Long Term measures like dam/storage reservoir for moderating flood is not possible at this stage because suitable sites are not situated in this state but these are in Nepal Territory. Flood embankments in a length of 3430 km. have been constructed so far along the rivers like Gandak, Burhi Gandak, Bagmati, Kamla, Kosi & Mahananda etc. to protect an area of 2.916 Million Ha. only out of total flood affected area of 6.88 Million Ha. Many small Himalayan Rivers have not been embanked or trained till now. These rivers are very much furious during the flood. Unexpected population growth, unplanned development activities (roads, bridges, culverts) carried by different govt. agencies have encroached the natural waterway, thus during flood it creates drainage congestion. Therefore, people are forced to live in flood or to face the flood menace every year. Though a lot of flood control works has been executed every year with the resource available for flood sector, people are not getting expected benefits. Methodology adopted in practice by the deptt. for planning, monitoring & construction of flood control works has been described here. But now, the need for a comprehensive study on river behavior, training & control has been felt in totality (Basin wise).

A holistic approach is required in detail hydrological study of each river of North Bihar taking the catchments area that lies in Nepal and other international boundaries. Climate change, its consequential effect and the likely statistical forecast, which can give a real scenario of the river behavior. The complete river models using satellite imagery and ground data shall be essential. The study of complete rivers of North Bihar and its behavior can work out possible sustainable solutions of disastrous flood issues in Bihar. The available models can be used for the study. A time frame of five years can be taken. The political will can give a sustainable solution for the benefit of people. In this background a study of North Bihar Rivers have been made with the latest modeling and simulation tool, the Soil and Water Assessment Tools (SWAT) and the results have been found encouraging in assessment of quality & quantity of water and sedimentation. Since SWAT is a public domain model containing 350 subroutines written in FORTRAN hence it is being modified and customized for Bihar Rivers for various purposes like flood forecasting, inundation mapping, climate change studies etc. for achieving sustainable solutions for flood issues.

Keywords

SWAT, FORTRAN, HYDROLOGY, CLIMATE CHANGE, FLOOD FORECASTING, INUNDATION MAPPING,

Characterization of climate and land use change impacts on blue and green water dynamics over the Ohio River basin

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Abstract

Impacts of climate and land use change on the overall water availability can be analytically comprehended in terms of long-term trends in blue water (BW; surface runoff and deep aquifer recharge) and green water (GW; soil water content and actual evapotranspiration). The objectives of this study are to: (i) conduct a comprehensive assessment of the spatial and temporal trends in BW and GW under the historical climate and land use conditions in the Ohio River Basin (490,000 km²) from 1935 to 2014; and (ii) quantify the relative effects of climate and land use changes on BW and GW. Soil and Water Assessment Tool (SWAT) is adopted to simulate the hydrologic fluxes for the entire basin, and the Mann-Kendall and Theil-Sen tests are employed to detect the statistical trends separately at the entire basin, regional, and sub-basin levels. Despite the overall volumetric increase in both BW and GW over the entire basin, the changes in their annual average values during the period of simulation reveal a distinctive spatial pattern. Results show that GW has increased significantly in the upper and lower parts of the basin in response to the prominent land use change in these areas, but BW has increased significantly only in the lower part in response to the precipitation change. Furthermore, by separating the contributions of climate and land use change, it is found that the effect of climate change on BW is more significant compared to GW. Land use change has increased GW remarkably, but has led to decreases in BW. The results from this study help understand the collective influence of natural and anthropogenic impacts on hydrologic responses in the Ohio River basin.

Keywords

SWAT, green water, blue water, climate change, land use change, Ohio, trend analysis

Impact of non-point source pollution on water quality of Pengxi River using SWAT model after 175-meter water project operation of the Three Gorges Dam

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Abstract

The degradation of water quality, extent of eutrophication and algae bloom in tributaries of the Three Gorges Reservoir (TGR) are becoming increasingly critical. Pollutants are mainly sourced from non-point source pollution in the reservoir, providing rich resources of nitrogen and phosphorus for algae growth. In addition to the nutrient inputs, the changes of hydrodynamic conditions also play an important role in water quality degradation and algae bloom problems. Since 2013, the Three Gorges dam has reached a sufficient water-level scheduling interval from 145 to 175 meters. Which not only changes the hydrodynamic characteristics of the tributaries, but also creates a 30-meter water-level-fluctuation (WLF) zone where agricultural activities are active in some areas. As a result, the soil and vegetation patterns in the 30-meter WLF zone have been altered evidently. Pengxi River is an important and representative tributary of the TGR. People living along the river like growing crops in the WLF zone during low-water-level period. Different degrees of algae bloom have been reported at Pengxi River since 175-meter impoundment. In order to investigate impacts of non-point source pollution on water quality, Pengxi River was studied in this study, with coupled SWAT model and one-dimensional hydrodynamic and water quality model.

For SWAT simulation, the different terrestrial conditions in Pengxi River basin based on 145-meter and 175-meter impoundment scenarios were analysed, especially the changes of land uses and agricultural practices within 30-meter WLF zone are mainly considered. For river water quality simulation, the one-dimensional hydrodynamic and water quality model was applied with using the SWAT results as confluent boundary conditions. The SWAT results showed that contaminants mainly sourced from 30-meter WLF zone led to significant increases of pollutant concentrations during 175-meter impoundment. Large amount of nutrients and residues left by agricultural practices in 30-meter WLF zone during 145-meter water-level period, were then brought into water body during 175-meter water-level period directly, contributing significantly to eutrophication. Secondly, along with the water depth rising, the flow rates was decreasing, in Pengxi River after 175-meter impoundment. When the pollutants residence time become longer, their degradation rates become lower comparing with the period before 175-meter impoundment. These changes create favorable environment for algae growth, further resulting in algae bloom. Prohibition of agricultural activities in 30-meter WLF zone is recommended.

Keywords

Three Gorges reservoir; Non-point source pollution; Pengxi River; SWAT model.

Research on watershed for non-point source pollution in the Three Gorges Reservoir based on SWAT

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Abstract

Three Gorges Project is the world's largest hydroelectric project, and it is of great importance on flood control and electric generation. The catchment of Three Gorges Reservoir (TGR) covers an area of approximately 58,000 km². It has more than 40 major sub-basins. With the country's strategic plan for making the Yangtze River become the golden waterway, the water pollution regulation of TGR is particularly important. Controlling non-point source pollution has gradually become an important control target since the cofferdam water impoundment of TGR. Exploring the differentiation regularity of TGR for non-point source pollution is important for the government to develop a scientific and rational water quality control program. To identify the main areas that caused pollution loads, the SWAT model was applied to simulate non-point source pollution in the large scale basin of TGR. The Three Gorges Reservoir basin was divided into 49 sub-basins. The land-use data in 2013 and soil data in 2013 were used in the model, and the land was classified into thirteen types. The soil data contain seven types. The SWAT model used in TGR had been in calibration and in validation by using hydrology and water quality data in 2006 and 2010. The R² Analysis and Nash Sutcliffe was used to analysis precision and predictive power of SWAT models which shows that the model was suitable to simulated non-point source pollution in TGR. The SWAT results also presented that pollutants in TGR were mainly nitrogen (N) and phosphorus (P). Due to a significant difference of rainfall, land use and soil type, the sub-basins of the Three Gorges Basin have different pollution load.

Keywords

Three Gorges Reservoir; SWAT; non-point source pollution

A Geospatial Modeling Interface (GMI) for SWAT Model Deployment and Evaluation

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Abstract

Geographical information systems (GIS) software packages have been used for nearly three decades as analytical tools in natural resource management for geospatial data assembly, processing, storage, and visualization of input data and model output. However, with increasing availability and use of full-featured geospatial data management tools, such as commercial (e.g., ArcGIS and IDRISI) and public domain open source (e.g., GRASS, Quantum GIS, MapWindow, uDIG) GIS, new issues have surfaced regarding application of natural resource models to a range of spatial scales and the role of geospatial data tools and analytical techniques in decision making. With increased availability of powerful PCs, cloud computing platforms, and web-based GIS tools and access to geospatial data sets, it is quite common to see natural resource models originally developed for small-scale, site-specific analyses now being applied to new domains/problems, and, through GIS, to very large areas to examine spatio-temporal variations in environmental impact assessment. This presentation provides an overview of the GMI (Geospatial Modeling Interface) simulation framework for SWAT model deployment and evaluation. In addition to SWAT, GMI also provides access to other environmental and agroecosystem models including AgroEcoSystem-Watershed (AgES-W), Nitrate Leaching and Economic Analysis 2 (NLEAP2), and Root Zone Water Quality Model 2 (RZWQM2). GMI data processing and visualization features include but are not limited to: 1) editing and visualization of geospatial model input data; 2) the ability to input measured experimental data for robust statistical model evaluation; and 3) geospatial output visualization across space, time, and modeling scenarios including capabilities for real-time post-processing (e.g., on-the-fly color ramping) and querying. GMI leverages an open source GIS platform that integrates Open Geospatial Consortium standards (as implemented in GeoTools – <http://www.geotools.org>) within NASA's World Wind Java SDK. The overall vision of the GMI development effort is the creation of a geospatial modeling framework that allows rapid integration of environmental models such as SWAT and enables/enhances the scientific modeling process through state-of-the-art geospatial visualization components.

Keywords

SWAT, Model visualization, Environmental modeling, GIS, Interface, Models, Geospatial analysis

Prioritizing Water Quality Improvement Efforts on Agricultural Lands Using Readily Available GIS Data

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Abstract

With the recent development and approval of several large-scale total maximum daily load (TMDL) projects in Wisconsin, a need for implementation targeting has been identified by the Wisconsin Department of Natural Resources and county land conservation staff. During the development of the TMDL, subbasins that contribute higher pollutant loads are identified, often through the application of models like SWAT. In order to implement management practices to reduce the loading from those subbasins, prioritizing needs to be done at approximately the field scale - the scale at which projects can be practically implemented. To address this need, the Wisconsin Department of Natural Resources has developed EVAAL - Erosion Vulnerability Assessment for Agricultural Lands. The GIS-based tool evaluates locations of relative vulnerability to sheet, rill, and gully erosion using readily available information about topography, soils, and land cover. This tool enables watershed managers to prioritize field-scale data collection efforts, thus saving time and money while increasing the probability of locating and addressing fields with high sediment and nutrient export. The current version of EVAAL uses assumptions regarding tillage types for various crop rotation practices. Since tillage practices, and the resulting amount of residue cover, can greatly impact erosion and nutrient export, it is advantageous to refine those assumptions. This is possible thru analysis of satellite imagery with the calculation of a normalized different tillage index (NDTI). This presentation will give an overview of EVAAL, show results of using Landsat imagery to map percent crop residue coverage and the associated tillage types, and demonstrate the resulting improvement in the EVAAL results.

Impacts of Input Datasets on SWAT Model Performance and Watershed Hydrology

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Abstract

SWAT requires a large set of input parameters and datasets to build the watershed model. Among such inputs are geospatial datasets of land use/land cover (LULC) and climate data. With availability of new datasets in the United States, such as NEXRAD and PRISM for climate and customized yearly NASS CDL maps for LULC, that can replace traditional network of relatively sparse NCDC weather stations and limited in land use categories NLCD land cover maps, SWAT model performance is expected to improve. However, SWAT model response to input dataset variability is not well documented and there exists only a few comparison analyses with regards to their impacts on watershed hydrology simulated by the model. The goal of the study was to evaluate the impact of three different weather datasets (NCDC, NEXRAD, PRISM) and crop rotation patterns in a customized LULC dataset on model performance and watershed hydrology in a western Kansas watershed. While gridded NEXRAD and PRISM datasets provided spatially continuous weather coverage, only PRISM improved SWAT model performance and better represented watershed hydrology. Due to limited radar coverage in the area of interest and unrealistic bursts of precipitation, NEXRAD overestimated runoff and streamflow. The SWAT model positively responded to the proper crop rotation pattern within the period of pattern observation, but the performance drastically declined for outside of the observation periods.

Keywords

SWAT; climate data; land use/landcover; NEXRAD; PRISM; NCDC

LUU_Checker: A Tool for Dynamically Incorporating New Land Uses in SWAT

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Abstract

The SWAT_LUC tool was released in 2011 that automated the process of creating an optional landuse update file (filename lup.dat) for updating hydrologic response unit (HRU) fractions during model simulation runs. The lup.dat file has enabled modelers to represent land use changes over the entire simulation run or initialize conservation measures during a chosen period in the middle of simulation run, as per user defined specifications. Despite saving time and errors in developing lup.dat file for large watersheds, the SWAT_LUC tool lacked the ability to simulate a new land use in the watershed that was not present in the base LULC data. The LUU Checker tool has been developed to develop a comprehensive raster data layer that allows accounting for new land uses that may emerge during the model simulation period. The presentation would include the development concepts and demonstration of LUU Checker tool.

Uncertainty Estimation of Hydrological Impacts of Bias-Corrected CMIP5 Climate Change Projections

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Abstract

Uncertainty estimation of climate change impacts has been recently given a lot of attention. It is generally assumed that the major sources of uncertainty could be linked to General Circulation Models (GCM) and Greenhouse Gases Emissions Scenarios (GGES). However, the other sources of uncertainty such as a choice of the observed climate dataset have been given less attention. In this paper, high spatial resolution of gridded datasets available in the United States, such as NEXRAD and PRISM, combining with traditional network of relatively sparse NCDC weather stations, were used to correct CMIP5 GCM outputs. We focus on investigating the uncertainties in quantifying the impacts of future climate projections bias-corrected by these three climate datasets on hydrology in a western Kansas watershed. The change factor method was used for bias correction of GCM outputs, and the SWAT model was used to simulate hydrological processes. Future (2070–2099) hydrological regimes were compared to the reference period (1970–1999) using the average hydrograph, annual mean discharge, peak discharge and time to peak discharge as criteria. The results showed that there was no substantial difference in temperature predictions based on these three corrected outputs of future scenarios. However, precipitation predictions are not as unequivocal as those of temperature, they vary depending on the historical datasets and also weather seasons. A significant variation in winter and summer discharges, as well as time to peak discharge were observed for future scenarios corresponded to three observed climate datasets. Across all variables, a large uncertainty envelope was found to be associated with the choice of the observed climate dataset, and it was compared to the envelope originated from 57 climate change projections from a combination of nineteen GCMs and three GGES. The differences among the observed climate datasets significantly contributed to the uncertainty envelope. Overall, we suggest that the climate change impact studies that use future projections bias-corrected on a climate dataset of land-based stations should be interpreted with caution.

Keywords

SWAT; Uncertainty; Bias-correction; Climate change; CMIP5; Hydrology

Hydrological change projection in the North Carolina Piedmont watershed by SWAT and bias corrected NARCCAP

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Abstract

This study focused on simulating future hydrologic change sensitivity by synergistic as well as de-convolved effects of CO₂ increment and projected climate in the North Carolina Piedmont watershed. As climate simulation data, a set of nested global and regional circulation model (GCM-RCM) precipitation and temperature from the North American Regional Climate Change Assessment Program (NARCCAP) were evaluated for historical time period, 1971 ~ 2000, before applying to the hydrologic model, the Soil and Water Assessment Tool (SWAT). General precipitation biases of five selected NARCCAP output are underestimation in fall and overestimation in spring and winter. NARCCAP temperature shows cold bias, especially in daily maximum temperature. After applying two simple statistical bias corrections methods, the LOCal Intensity (LOCI) scaling method (Schmidli et al., 2006) for precipitation and Fourier functions for temperature, NARCCAP outputs showed significant reduction of seasonal biases except for a few extreme events. Application of historical time original and bias-corrected NARCCAP to the SWAT also showed that bias-corrected NARCCAP produced more reliable stream discharge than original NARCCAP. Projected NARCCAP precipitation is similar or has a small increase with a temperature increasing by 1 – 5°C in 2041 – 2070 in North Carolina Piedmont. Under projected climate and CO₂ condition, evapotranspiration (ET) was simulated to increase noticeably especially in winter and spring while water yield (WY) showed various changing patterns, with great dependence on CO₂ and precipitation. The highest WY was simulated by combination of increasing CO₂ and projected precipitation while projected temperature alone simulated the lowest WY. SWAT simulation results showed that it is necessary to incorporate interactions of CO₂ and climate change to simulate future water availability in North Carolina Piedmont.

Keywords

SWAT; NARCCAP; statistical bias correction; CO₂ increment; North Carolina Piedmont

Mapping Ground Water Recharge Rates in Southwest Michigan under Multiple Future Climate Simulations

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Abstract

This study used the Soil and Water Assessment Tool (SWAT) to map rates of ground water recharge under various projections of future climate in Southwest Michigan. The following five river basins were modeled with SWAT: the Kalamazoo, the Paw Paw, the headwaters of the St. Joseph (of Indiana and Michigan), the Thornapple, and Upper Dowagiac. Each model was developed using observed weather data from 1995 to 2010, which were originally interpolated to grid points by [Maurer et al. \(2002\)](#). To best simulate ground water hydrology within SWAT, the models were calibrated at multiple USGS stream gages to base flow conditions. The models were also adjusted to align with published rates of evapotranspiration, published estimates of base flow separation, irrigation rates reported to Michigan Department of Environmental Quality, and county-level crop yield estimates. The models were then run forward with future climate data organized and down-scaled by [Hayhoe et al. \(2013\)](#) to the grid points generated by Maurer et al. These climate projections included 10 different models, each under two to three different scenarios (A1B, A1fi, A2, B1). SWAT outputs projected overall increases in ground water recharge rates through the end of the century, mainly attributable to increases in precipitation within the different climate scenarios. However, recharge rates increased sharply towards the end of the century in climate scenarios in which CO₂ is projected to be high (A1fi). These higher rates were attributable to decreases in projections of evapotranspiration, which were due to decreasing leaf conductance as CO₂ levels rose.

Keywords

ground water, recharge, climate change, Michigan

Quantifying the Effects of Climate Change on Runoff, Sediment and Chemical Losses for Different Watershed Sizes

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Abstract

Assessing the sensitivity of agricultural watersheds to possible changes in future climate is imperative when developing appropriate management practices. Despite numerous studies on the impact of climate change at different local and regional scales, it is still necessary to evaluate the impact of these changes on highly agricultural watersheds with modified hydrologic landscapes.

Like much of the Midwest, the hydrology in northeastern Indiana is dominated by subsurface tile drainage supplemented with surface drainage of closed depressions (potholes). The closed depressions are sites within the landscape formed from glaciation, and in which runoff water tends to collect because there is no natural outlet. In order to maximize crop production, farmers often install tile risers (a vertical tube that connects the bottom of the low point of a closed depression with the subsurface tile drainage network) to drain the closed depression. According to the United States Global Change Research Program (USGCRP), precipitation in the Midwest is likely to fall more frequently in heavy downpours (projected to occur two to three times as often by 2100). The duration and intensity of precipitation events will have direct influence on surface runoff, which often transports sediment, pesticide and nutrients to rivers and streams. However, this influence could be more severe in agricultural watersheds with significantly modified watershed hydrology.

In this study, the Soil and Water Assessment Tool (SWAT), and downscaled weather data generated using the MarkSim weather file generator was used to evaluate the potential impact of changes in temperature, rainfall and solar radiation on streamflow, sediment and chemical losses in the hydrologically modified Cedar Creek, F34, AXL and ALG watersheds located in northeastern Indiana.

Keywords

climate change, MarkSim, modeling, SWAT, water quality

Comparative Analysis of Spatial Resolution Effects on Standard and Grid-based SWAT Models

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Abstract

Traditional spatial representation of the Soil and Water Assessment Tool (SWAT) utilizes common soil, land use, and slope when discretizing a landscape. While computationally efficient, such an approach relies upon routing landscape processes at the subwatershed scale, thereby ignoring spatial interaction among adjacent landscape units. To overcome such limitations, a grid-based version of the SWAT model, SWATgrid, was developed to perform landscape simulation on a regularized grid and employ a modified landscape routing algorithm to spatially connect them during routing. However, SWATgrid remains largely untested with little understanding of the effect of user defined grid cell size. Moreover, increases in computation time effectively preclude direct calibration of SWATgrid, instead necessitating parameter transfer from a standard SWAT model. Therefore, to gain insight into defining an appropriate range of spatial resolutions for future SWATgrid application, this research considers two objectives: 1) effect of input data spatial resolution on model output, and 2) effect of scale on calibrated parameter distributions. Baseline SWAT input data, nominally at 30 m, was rescaled for a range of resolutions up to 1,000 m. Impacts of input data spatial scale were considered by calibrating a standard SWAT model and holding calibrated parameters constant. Standard and gridded SWAT models were compared relative to simulated hydrology and water quality over coarsened scales as defined by the rescaled input data. Differences in predictions were analyzed with respect to both model type and resolution. Conversely, parameter sensitivity to scale was evaluated by individually calibrating standard models at all resolutions and examining parameter congruency or divergence. Results indicate that: 1) the gridded approach underpredicts simulated streamflow relative to both observed and simulated data from standard SWAT output and 2) parameters may be transferable up to a grid size of 90 m. Overall, results from this analysis serve to better define optimal applications of the SWATgrid model as well serve as a general guideline in determining ideal spatial resolutions for future simulations.

Keywords

grid; resolution; calibration

Improved physical representation of vegetative filter strip in SWAT

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Abstract

Quantification of effectiveness of conservation practices is critical in precision conservation planning. Vegetative Filter Strips (VFS) is a popular conservation practice in USA, installed at the edge of agricultural fields to reduce sediment and nutrient losses from intensively managed agricultural areas. Soil and Water Assessment Tool (SWAT) is widely used to quantify the environmental effects of VFS. In current SWAT model, VFS area is considered as conceptual area with regression models to represent its effectiveness in improving water quality. This study is aimed to improve the physical representation of VFS in SWAT model to improve ecohydrologic process representation and to quantify biomass productivity of VFS area. The proposed framework creates explicit VFS area and enables routing of water, sediment and nutrients from source area through the VFS area. Additionally, it makes the infiltrated water and nutrients available for crop uptake in the VFS area. The proposed improvements are implemented in SWAT model by modifying input files through Matlab scripts and also by changing SWAT filter strip algorithm to enable routing. The developed framework is tested with three paired watershed studies with and without edge of field VFS in the Central Iowa. The results indicate improved physical representation of VFS in SWAT model.

Keywords

Vegetative filter strips, SWAT model, Energy crop BMP, nonpoint source pollution, conservation measures.

Coupling aquatic nutrient simulation module (NSMI) and SWAT model

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Abstract

This paper presents the development of aquatic nutrient simulation module (NSMI) and its coupling with SWAT model. The NSMI, developed by the Environmental Laboratory of Engineer Research and Development Center, is a “plug in” water quality module for existing hydrologic and hydraulic models. The NSMI models algae and benthic algae, simplified nitrogen, phosphorus and carbon cycles, organic matter, carbonaceous biochemical oxygen demand, dissolved oxygen and pathogen using 16 state variables. Water quality state variables included in NSMI can be individually activated or deactivated. Various kinetic processes and equations in NSMI have been critically tested and verified before, and the focus here is on its coupling with SWAT and a real world project evaluation. The SWAT - NSMI was applied to the Little river watershed for the assessment of instream flow water quality.

Keywords

nutrient simulation module, water quality, SWAT

Comparison of multiple point and single point calibration performance for the Saginaw River Watershed

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Abstract

The Soil and Water Assessment Tool (SWAT), which is a comprehensive physically based model for watershed/water quality assessment, uses several inputs including soil, elevation, slope, land use and climate data. The parameters used by SWAT have their own default values which must be modified for each developed model during the calibration process. In this study, we calibrated a SWAT model for the Saginaw river watershed, which is the largest six digit Hydrological Unit Code (HUC-6) in Michigan with more than thirteen thousands reaches. Furthermore, this region is defined as an area of concern by the Environmental Protection Agency (EPA). Two approaches were used for stream flow calibration: 1) using a single calibration point close to the watershed outlet and 2) using eight observation points and performing a multi-step calibration.

Three statistical criteria including Nash–Sutcliffe model efficiency coefficient (NSE), percent bias (PBIAS) and root mean square error to the standard deviation of observation data (RSR) were used to evaluate the stream flow calibration process. Using single point calibration, assumes that the entire watershed has the same conditions and the changes made to the default parameter values will be applied everywhere. In contrast, multiple point calibration splits the region into smaller areas which are calibrated separately. This allows us to apply different sets of parameter values for each area within the region. Results showed that the second approach will outperform the calibration process and will allow us to capture spatial variations within the watershed.

Keywords

SWAT, Watershed modeling, Saginaw, Calibration

Evaluating weather observations and the Climate Forecast System Reanalysis as inputs for hydrologic modeling in the Hawaiian Islands

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Abstract

Correctly representing weather is critical to hydrological modeling, but scarce publically available, inconsistent, or poor quality observations can potentially compromise hydrologic model accuracy. Reanalysis datasets may help to address this basic challenge. The Climate Forecast System Reanalysis (CFSR) dataset provides continuous records from 1979 to today, and have produced satisfactory hydrological model performance in tropical montane Puerto Rico between the Caribbean Sea and the North Atlantic Ocean, as well as some temperate and monsoonal locations. However, the use of CFSR for hydrological modeling in tropical basins in the Pacific has not yet been carefully evaluated. For the islands of Kauai and Hawaii, we compare model performance based on CFSR records with performance based on publicly available weather stations in the Global Historical Climate Network (GHCN) and the United States Geological Survey (USGS). Autocalibration of individual SWAT models for each of the available USGS stream gage basins was performed against each of the available weather datasets. This study demonstrates the need to evaluate available weather inputs, while introducing the CFSR as a lower threshold to evaluate hydrological model performance.

Keywords

weather data, CFSR, autocalibration, Hawaii

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