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Toulouse France

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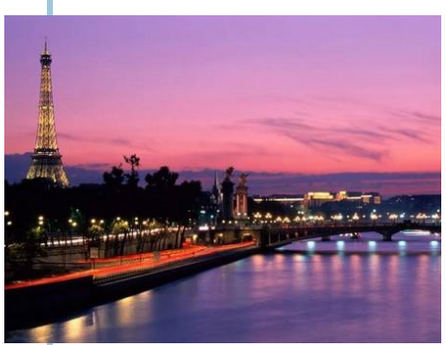

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Book of Abstracts

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

The organizers of the 2013 International SWAT Conference want to express their thanks to the organizations and individuals involved and their preparation and dedication to coordinate a successful conference. 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.

A special thank you to Paul Sabatier University and Drs. José Miguel Sánchez-Pérez and Sabine Sauvage for their countless hours and efforts to host the SWAT Community. On behalf of the SWAT Community, we extend our sincere gratitude to you and your university for the kind invitation and welcoming hospitality.

The following Book of Abstracts contains abstracts for presentations covering a variety of topics including but not limited to large scale applications; climate change applications; model development; database and GIS application and development; environmental applications; hydrology; best management practices (BMPs); sensitivity, calibration and uncertainty; pesticide, bacteria, metals and pharmaceuticals; sediment, nutrients, and carbon, urban processes and management; and more.

The Conference Organizers hope you enjoy the conference and continue to view these SWAT gatherings as a positive opportunity for our international research community to share the latest innovations developed for the Soil and Water Assessment Tool.

Preface

We are very pleased to host the 2013 International SWAT Conference and welcome the SWAT network to Toulouse. We want to thank Srini, Jeff, and all of the SWAT staff for their confidence. In just five years, we have developed an extensive collaboration with the SWAT team in Texas, and also with other teams located around the world. This effort is evident today with the organization of the developer's meeting few days before the conference.

SWAT has opened our borders. Collaborations using SWAT model do not stop multiplying after India, Canada, Spain, Portugal, China, and Cuba. We will soon launch new collaborations with Italy, Algeria, Morocco, Paraguay, Argentina, Brazil, and Japan.

More than 200 people from 40 countries and all continents are registered for the conference which will consist of four parallel sessions totaling 144 oral presentations and 24 poster presentations in 11 topics. The most represented topics are hydrology, large scale applications and model development.

For this conference, we wanted to give special recognition to young researchers. We gave ten scholarships to young students from seven different countries. We have also planned a meeting between young and senior researchers, led by a Ph.D. student from our lab, Mr. Cyril Garneau.

We want to first thank all our sponsors for their financial support. Then we would like to thank all the permanent staff from Ecolab and University Paul Sabatier, fellows, volunteers, masters, and doctoral students who helped organize the conference for several months. We especially want to thank Miss Sun Xiaoling, Mr. Cyril Garneau, Mr. Youen Grusson, Mr. Yi Hong, and Mr. Léonard Bernard Jannin for their strong commitment and investment. A special thanks to Marie-Ange Albouy for the coordination of the local organization at the Paul Sabatier University, and to Claire Baffaut, for her help coordinating with the French Embassy in USA, and finally to Jaclyn Tech for her very good job and availability.

We hope you enjoy the conference and take the opportunity to share the different water resources problems encountered in your own country with others. In developing countries where data is difficult to acquire, we believe a tool like SWAT along with the acquisition of new data by non-invasive techniques such as remote sensing could help to better manage water in the future. A better understanding of modeling processes related to the quantity and quality of water is one of our daily concerns and we hope that the SWAT network serves to support the transfer of skills and knowledge without any limits beyond borders around the world.

Sabine Sauvage and José Miguel Sánchez-Pérez, Toulouse, France

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International Organizing Committee

Dr. José Miguel SANCHEZ PEREZ
Research Director, CNRS, France

Jose Miguel Sánchez-Pérez, has a Ph.D. (1992) in Hydrogeochemistry in the University of Strasbourg (France); M.S. (1985) in Geology from University of the Basque Country in Spain. He is currently a research director assigned to ECOLAB Laboratory (CNRS - Université Paul Sabatier - Institut National Polytechnique de Toulouse) in Biogeochemical functioning of buffers zones.

José Miguel Sánchez-Pérez studies pollutant transport in hydrosystems, using extensive field data and modeling. He specializes in the functioning of wetlands, riparian zones, and groundwater systems, with particular interests in the modeling of catchment-scale pollutant transport, to predict how ecosystem functions will change under various climate change scenarios. For more details see: https://gmod.olympe.in/index.html

Dr. Sabine SAUVAGE
Research Engineer, CNRS, France

Sabine Sauvage holds a Ph.D. from the Institut National Polytechnique, Toulouse University, FRANCE. She is currently a Research Engineer at the National Center for Scientifical Research (CNRS) in the National Institute of Ecology and Environment. She is currently assigned to ECOLAB laboratory at Toulouse, and has been working on transfer modeling of contaminants in river water systems for 13 years.

Her research interests are focused on the adaptation and development of models that describe the bio-physical interactions between flows, biology and chemistry processes involved in biogenic elements and contaminants transfers in rivers at different time and space scale. More specifically, she aims to integrate by modeling the particular role of interfaces zones (ex: water/land, water/sediment) and specific buffer zones (ex: wetlands) in the dynamic of element transfer at large scale. For more details see: https://gmod.olympe.in/index.html

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Dr. Claire BAFFAUT
Research Hydrologist, USDA-ARS, USA

Claire Baffaut holds an engineering degree from the School of Hydraulic Engineering in Grenoble, France and a Ph.D. from Purdue University, USA. She is currently a research hydrologist with the USDA-Agricultural Research Service (ARS) in the Cropping Systems and Water Quality Research Unit.

Her research interests include modeling watershed and landscape processes, developing practical tools to identify areas that need particular attention, and developing alternative agricultural practices for improved watershed management under changing land use, climate, and economic constraints.

Dr. Jeff ARNOLD
Agricultural Engineer, USDA-ARS, USA

Jeffrey G. Arnold has a Ph.D. (1992) in Agricultural Engineering from Purdue University; M.S. (1983) in Agricultural Engineering from University of Illinois; B.S. (1981) in Agricultural Engineering from University of Illinois. He is currently an Agricultural Engineer at the USDA-ARS, Grassland Soil and Water Research Laboratory in Temple, Texas.

Jeffrey G. Arnold develops watershed scale hydrologic and water quality process modules and integrates the processes within the SWAT model. He also actively supports application of the model for regional and national conservation and environmental assessments.

Dr. Raghavan SRINIVASAN
Professor, Texas A&M University, USA

Dr. Srinivasan has a Ph.D. (1992) degree in Agricultural Engineering from Purdue University. He is currently a professor in the departments of Ecosystem Science and Management, and Biological and Agricultural Engineering at Texas A&M University, as well as director of the Spatial Sciences Laboratory.

Dr. Srinivasan has become known and respected throughout the world for his developmental work with spatial sciences and computer-based modeling, especially the Soil and Water Assessment Tool. His research and its applications have contributed to long-lasting changes in natural resource assessments and development of management system options, currently being used in more than 90 countries.

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Estimation of Actual Evapotranspiration at Regional – Annual scale using SWAT

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Abstract

The aim of this study was to estimate actual evapotranspiration at regional – annual scale using SWAT model. For this reason, SWAT calibration and validation was done based on river discharge data from 5 gauging stations, rainfed and irrigated wheat yield data for the period Oct. 2000 to Sep. 2007 and Oct. 2007 to Sep. 2010, respectively. Because of the direct relationship between crop yield and evapotranspiration, calibration of watershed models using crop yield along with river discharge gives more confidence on the partitioning of water between soil storage, actual evapotranspiration, aquifer recharge. Results showed that SWAT provided satisfactory predictions on hydrologic budget and crop yield. Specifically, calibration (R2 = 0.82, NS=0.79) and validation (R2 = 0.71, NS=0.71) periods were quite suitable for the outlet of watershed. It also was able to predict crop yield satisfactorily for irrigated wheat in which R-factor and RMSE values were 0.97 and 0.08 ton ha^{-1}, respectively. The multi-objective calibrated model was then used to estimate and analyze the actual evapotranspiration. Mean ten-year actual evapotranspiration and precipitation was estimated 230 and 270 mm, respectively. The ten-year actual evapotranspiration to precipitation ratio at mountainous part of watershed was 99%, 80% and 77% for 2000-2001 as a dry year, 2001-2002 as a normal year and 2004-2005 as a wet year, respectively. Groundwater is an important source of water supply in the Neishaboor plain. Therefore, estimation of this ratio is not as simple as mountainous part of watershed due to uncertainties in the crop pattern data and their water requirements. It is obvious that this ratio could be more than one in some years especially dry years.

Keywords

Actual evapotranspiration, SWAT, river discharge, crop yield and Neishaboor watershed

Development of Modeling System Based on the SWAT Model as a Tool for Water Management Institution

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Abstract

The Soil and Water Assessment Tool (SWAT) model has been used extensively in many countries and for many different applications connected to water environment. The great majority of these applications were done on the temporary basis of scientific projects. However, for the exception of the United States, there is lack of examples on the acceptance of this model by regulatory bodies, which would invest in its application as a long term strategy to answer management questions. The Environmental Protection Agency of Lithuania (EPAL) has committed itself for such a task in order to increase its capacity in solving questions related to non-point source (NPS) water pollution problems. NPS pollution is responsible for the largest part of degradation in water ecosystems occurring in the country. Activities commenced by the EPAL included: testing the SWAT model for pilot basin, building country scale detail modeling system, the continuous collection of relevant data and the adaptation of data collection to fill the SWAT model requirements. Additionally, model applications are currently designed for many tasks such as the assessment of water quality, the assessment of pollution sources responsible for the degradation of water bodies, assessment on the effectiveness of NPS pollution abatement measures, the optimization of spatial distribution of such measures, the assessment of impacts of structural agricultural changes on water environment, etc. The aim of this article is to communicate information on the progress of the SWAT model application in Lithuania and about major encountered challenges.

Keywords

Lithuania, SWAT model, modeling system, water management.

Simulated Impacts of Three Decadal Climate Variability Phenomena on Water Yields and Urban Water Security in the Missouri River Basin

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Abstract

The Missouri River Basin (MRB) is the largest river basin in the U.S. and is one of the most important crop and livestock-producing regions in the world. The MRB covers more than 500,000 square miles (~1,280,000 square km) and a part or all of 10 states, parts of two Canadian provinces, and is home to 28 Native American tribes. Inhabitants of the MRB depend on the river system for drinking water, irrigation and industrial needs, hydro-electricity, recreation, navigation, and fish and wildlife habitat. The MRB produces approximately 46% of U.S. wheat, 22% of its grain corn, and 34% of its cattle. About 117 million acres (~47.35 million ha) are in cropland, with 12 million acres (~4.86 million ha) under irrigation. The MRB contains some of the country's most sparsely-populated agrarian counties, as well as 2344 urban communities. Thus, almost 90% of the MRB's cropland is entirely dependent on precipitation and strongly competing with urban areas for water, with both uses heavily influenced by climate variability and change. Therefore, it is very important to assess and predict, if possible, climate variability and change impacts on MRB water.

In a study of associations between decadal climate variability (DCV) phenomena and hydro-meteorological (HM) variability in the MRB, we found that positive and negative phases of the Pacific Decadal Oscillation (PDO), the tropical Atlantic sea-surface temperature gradient variability (TAG), and the west Pacific warm pool (WPWP) temperature variability were significantly associated with decadal variability in precipitation and air temperature in the MRB, with combinations of various phases of these DCV phenomena associated with drought, flood, or neutral HM conditions. Here, we report on a methodology to assess whether the aforementioned DCV phenomena directly affect the hydrology of the MRB. The Hydrologic Unit Model of the U.S. (HUMUS)-Soil and Water Analysis Tool (SWAT) system was used to simulate water yields in response to realistic values of the PDO, TAG, and WPWP at 75 widely distributed, eight-digit hydrologic unit areas within the MRB. HUMUS-SWAT driven by HM anomalies in both the positive and negative phases of the PDO and TAG resulted in major impacts on water yields, as much as ±20% of average water yield in some locations. Impacts of the WPWP were smaller. Thus, our results show that the combined and cumulative effects of these DCV phenomena on the MRB HM and water availability can be dramatic with important consequences for the MRB.

We also report on the application of the HUMUS-SWAT system to simulation and prediction of DCV impacts on water supply and demand in Great Falls, Montana; Lincoln, Nebraska; and Kansas City—small, medium and large urban areas in the MRB. In this study, we find that simulation of water yield, ground water, and evapotranspiration by the HUMUS-SWAT system, driven by observed HM variables in the Great Falls and Lincoln urban areas, correlate highly with independently measured water supply and demand of their urban water systems. Analyses for the Kansas City urban area is in progress. Thus, in addition to its utility in general hydrology, the HUMUS-SWAT could be useful in management of urban water systems as well.

Evaluating Crop and Water Yields in the Missouri River Basin using SWAT

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Abstract

The Missouri River Basin (MRB) covers around 1280000 sq. km across ten states in the USA. The basin has 47.35 million ha in cropland, with 4.86 million ha irrigated and produces approximately 46% of U.S. wheat, 22% of its grain corn, and 34% of its cattle. The goal of this study is to capture the spatial and temporal variability of hydrologic and land management patterns across the basin and to evaluate the crop and water yields using SWAT model. This was evaluated by dividing the entire basin into three basins (Upper, Middle and Lower) and a separate SWAT model was setup for each of the three basins. The Upper, Middle and Lower basins has a total of 4831, 5695, and 2939 sub-basins, respectively. In addition, CDL and MODIS-Irrigated land layers were combined to prepare a land use/land cover map for each of the three basins at 30m resolution that has both crop rotations and irrigated lands included and the STATSGO (USDA-NRCS, 1995) 1:250,000 scale soil map was used in this study. Weather data input was from the historical daily precipitation and temperature data from 1949 to 2010 downscaled to grid points that are spaced at 462 x 222 grid (0.125° x 0.125°) covering the entire basin. The traditional approach of calibrating the model only at the basin outlet cannot account for hydrological and land management differences across a large scale basin as the MRB. Therefore we have selected eleven zones representing unique land use and hydrology patterns. A watershed (appox.4000 sq. km) in each zone was selected and calibrated both manually and by auto calibration using the SWATCUP program against observed stream flow data and crop yields. The calibrated parameters from each of the selected watershed were assigned to all sub-basins in the entire zone, and thereby account for spatial and temporal variability of hydrologic and land management patterns across each basin. Water yields at various locations in each basin will be evaluated. County level corn, soybean, winter and spring wheat yields in rain-fed and irrigated areas will also be evaluated. This will help us in analyzing the spatial and temporal distribution of crop and water yields in the Missouri river basin.

Evaluation of Model Calibration and Uncertainty Analysis with Incorporation of Watershed General Information

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Abstract

For applications of complex watershed simulation models, it is always a challenging task to calibrate model parameters. A large number of optimization techniques have been developed to solve high dimensional problems by comparing error statistics calculated based on the time varying hydrologic/nutrients responses such as stream flow and nitrate loads. However, model outputs can also be intra-watershed responses such as denitrification and N-nitrate yields from surface or subsurface flow. Therefore, it is possible that results of model calibration based on only sequential responses may violate actual watershed behavior because intra-watershed responses are not considered while computing error statistics. Consequently, model calibration without including watershed general information may have model parameters converging to domains with physically unreasonable outputs but in excellent statistics. In this study, the intra-watershed responses are applied on model calibration via additional constraints. The new approach of parameter estimation is implemented at the Eagle Creek Watershed in central Indiana. The results show noteworthy improvement on overall performance in minimizing objective function, increasing number of behavioral solutions and the quality of predictive outputs is also significantly enhanced. The use of additional constraints in reflecting intra-watershed responses indicates great potential in enhancing the quality of watershed calibration, which provides a new direction for future work of watershed modeling.

Parameter calculation of SWAT model using field observed data in the freeze-thaw agricultural area

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Abstract

To better fit the non-point source pollution analyse in china, calculating the parameter threshold of SWAT model based on field observed data is essential to ensure the model accuracy. The field observed data was analyzed with six parameters which provided detailed information in model parameter. The parameters were calculated by the mathematical formula and model. The key parameters of SWAT model were obtained, including AWC (available water capacity), SOL-NO_3 (initial NO_3 concentration), SOL-ORGN(initial organic N concentration),SOL-SOLP (initial soluble P concentration), SOL-ORGP(Initial organic P concentration), OM(The percent organic matter content) in the soil layer and USLE-K(USLE equation soil erodibility (K) factor). AWC of permanent dry land, paddy land reclaimed from the dry land, permanent forestry, dry land reclaimed from the forestry, permanent wetland and dry land reclaimed from the wetland were 0.12, 0.11, 0.11, 0.11, 0.14, 0.11 cm/cm separately while there was little difference among different land types. SOL-NO_3 of permanent dry land, paddy land reclaimed from the dry land, permanent forestry, dry land reclaimed from the forestry, permanent wetland, dry land reclaimed from the wetland and paddy land reclaimed from the wetland were 1045.935, 964.500, 1215.736, 1172.819, 1690.468, 1100.916, 1010.549 mg/kg separately. The highest SOL-NO_3 occurred in the permanent wetland while the lowest in the paddy land reclaimed from the dry land. SOL-ORGN of seven land types were 1728.043, 1439.025, 1913.517, 1653.846, 3917.887, 1732.461, 1424.590 mg/kg separately. SOL-ORGN in the permanent wetland was far high than six other land types. SOL-SOLP of seven land types were 30.325, 12.104, 9.075, 18.852, 16.996, 34.539, 11.932 mg/kg separately. The highest SOL-SOLP occurred in the dry land reclaimed from the wetland while the lowest in the permanent forestry. SOL-ORGP of seven land types were 216.005, 179.878, 239.190, 206.731, 489.736, 216.558, 178.074 mg/kg separately. The highest SOL-ORGP occurred in the permanent wetland while the lowest in the paddy land reclaimed from the wetland. OM of seven land types were 4.161%, 3.465%, 4.608%, 3.982%, 9.434%, 4.172%, 3.430% separately. The highest OM occurred in the permanent wetland while the lowest in the paddy land reclaimed from the wetland. USLE-K of permanent dry land, paddy land reclaimed from the dry land, permanent forestry, dry land reclaimed from the forestry, permanent wetland and dry land reclaimed from the wetland were 0.1836, 0.1840, 0.1779, 0.1799, 0.1765, 0.1805 separately. There was little difference among the different land types. The parameters of different land types were obviously different due to the different observed data. SOL-ORGN and SOL-ORGP of the permanent wetland were far higher than six other land types because of high organic matter content while those of the paddy land reclaimed from the wetland were lowest because of lowest organic matter content. There was little difference on AWC and USLE-K of different land types for The same texture of sandy loam. Comparison of calculated and simulated parameter value indicated that all parameters of two methods were not equal. A sensitivity analysis revealed that for the modeling of the nitrogen and phosphorus loss, some parameters were identified as most sensitive.

EuroSWAT: Comparing calibrated parameter sets for the Scandinavian Peninsula and for the Iberian Peninsula

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Abstract

The SWAT model is currently being used at the Joint Research Centre of the European Commission as a modeling platform to predict water and nutrient losses due to anthropogenic activities at European Scale. A modeling protocol was proposed by Pagliero et al. (2012) to deal with large-scale applications. This modeling protocol involves regionalization and step-wise calibration. In this context, we examine the spatial variation of calibrated parameter sets for streamflow obtained for head sub-basins in two very different regions of Europe: Scandinavia and the Iberian Peninsula. There are two main research questions: a) what are most relevant hydrological processes in each region? b) what is the spatial variation in parameter optima in these regions? Results show that snow processes are relevant in Scandinavia and groundwater processes are significant both in Scandinavian and Iberian Peninsulas. Instead, lateral flow processes are not significant. In addition, optimal soil hydraulic parameters have different ranges of values in each region, reflecting a difference in runoff generating mechanism between studied regions.

Keywords

Large-scale application, SWAT, SUFI-2, sensitivity analysis, spatial variability, Scandinavia, Iberian Peninsula

Uncertainty Analysis of Non-point Source Pollution modeling: an important implication for the application of Soil and Water Assessment tool

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Abstract

Uncertainty is inherent in watershed modeling but is not fully acknowledged in the process of model application. This review will focus on the topic of the uncertainty issues of the Soil and Water Assessment Tool (SWAT) model which is one of the most useful tools to simulate nonpoint source pollution (NPS) processes. A number of literatures are investigated and three sources of uncertainty, including the modelinput, parameter and model structure are discussed in details. It is indicated the rainfall data, in terms of spatial rainfall variability and the accuracy of measured data, plays a key role in the accuracy of SWAT.The GIS inputs, including digital elevation model (DEM), land use map and soil type map, are also identified by researchers as key sources of input uncertainty. As for parameter uncertainty and model structural uncertainty, it is anticipated that the complex, nonlinear structure and numerous parameters of SWAT may result in the unidentifiability of parameters and the phenomenon of equifinality. Some widely-used uncertainty analysis methods, such as the Generalized Likelihood Uncertainty Estimation (GLUE) and First-Order Error Analysis (FOEA), are also analyzed and compared to provide reliable guidance in an actual application of SWAT. This topic in our manuscript will benefit a wide range of readers concerned about uncertainty issues in NPS modeling and be also of particular interest to the readers with offering a better knowledge for the application of SWAT to develop watershed programs.

Keywords

Model input uncertainty; parameter uncertainty; model structural uncertainty; SWAT

Influence of different agricultural practices on nitrate–nitrogen (NO3-N) leaching - Experiences in the Drava catchment, Slovenia

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Abstract

The aim of research was to determine how changes in the management of agricultural land (cultivation technics, fertilisation, type of crop, crop rotation) influence on the leaching of nitrogen from the soil profile in the Drava river plain in Slovenia. We created thirteen different scenarios of potential agricultural land management. Research was conducted in three research polygons, located on the shallow alluvial bedrock with carbonate and silicate layers, which is the main source of drinking water in the area. Results of the Soil and Water Assessment Tool model version 2009 showed that magnitude of nitrogen leaching from the soil profile is influenced by soil properties and type agricultural land management. The most drastic effect on the increase of nitrogen leaching showed vegetable production technology, followed by cereals (corn, wheat, barley). Effects of grassland production may lead to 76 to 98% reduction in nitrogen loss from soil profile in comparison to current practices.

Exploring Adaptation Options to Climate Change in Semi-Arid Watershed Using Choice of BMPs

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Abstract

BMPs are those field operations which promote efficient use of resources, safety for stakeholders, and sustainable management of water resources. The choice of practices of the BMPs will vary from watershed to watershed due to varying characteristics. The present study has been conducted to explore adaptation options to address implications on account of climate change impact assessment in Karkheh River Basin (KRB). SWAT model has been used for impact assessment analysis. The model was calibrated using the baseline information. The results of climate change impact were obtained by using the future climate condition. It has been found that there should be explicit deficit in water and crop yield during the end century (2070-2099).

SWAT model has wide spectrum of abilities to manage the cultivation field operations. These operations are relevant to rain-fed and irrigated farming areas. In the KRB, such cultivated area account for about 25 percent of the total area. It has been decided to explore the adaptation options to account for the deficit in water availability through proper selection and deployment of suitable BMPs. Four of them have been selected for this study: i) Terracing, ii) Contouring, iii) Filter Striping and iv) Strip Cropping. These selected BMPs has been examined with future ‘PRECIS’ and ‘REMO’ regional climate models dynamically downscaled from the latest GCMs.

Keywords

SWAT Model; KARKHE River Basin; Best Management Practices (BMPs); Field operation; Adaptation

Modeling the dynamics of agricultural landuse and practice changes with GENLU2 - a SWAT application

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Abstract

To help local managers in their decision making for restoring surface water quality, SWAT has been carried out in the context of an integrated modeling process. The concern is focused on nitrate and pesticide concentrations, within two watersheds Né (690 km2) and Boutonne (1300 km2) located in Southwestern France. The agricultural systems and associated practices, heterogeneous in the area, were previously described using typologies (crop rotations * types of soil). At this scale, the SWAT model allows to take into account the diversity and variability of the natural and anthropized systems. But implementing land-use changes on HRUs or sub-basins through the standard GIS interface can be very tedious. Therefore we developed a tool, GENLU2 that builds up, from the typology of soils and agricultural systems, management schedules in a read-in format for the SWAT2009 program database. GENLU2 mainly automates the implementation of land-use and agricultural management changes and assigns them at the HRU scale. For each rotation, GENLU2 decodes it into a succession of single crops. Then it reassembles the management schedule of the rotation and assigns it at the HRU scale.This ability of building up read-in SWAT evolutional scenarios makes GENLU2 an appropriate tool for implementing the SWAT model with complex landuse and agricultural systems. It simplifies the work for assessing the pollution pressure in reference to a baseline scenario, at different scales and time steps. GENLU2 benefits have been assessed by confronting the relevance of the crop rotations modeled by SWAT with those used by agro-environmental indicators

A process-based method to simulate terraces in SWAT

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Abstract

Terraces are effective for controlling high soil loss. In the Soil and Water Assessment Tool (SWAT), terrace effects are simulated by adjusting the slope length and the USLE P-factor. A process-based algorithm was developed and incorporated into SWAT (version 2009) to simulate the environmental effects of normal and bench terraces at the Hydrological Response Unit level. Terrace description, storage effects and the flow interaction between the terraces and the HRU were introduced in the method. Flow, sediment, nutrient and herbicides are routed from the field through the terrace and its channel to a grass waterway, a lined channel or an underground outlet. The modified SWAT model was evaluated at the field scale using a 4-year long runoff and sediment data set from a terraced field in southeast Franklin County, Kansas. Results indicated that the model did a satisfactory and consistent prediction in simulating runoff and sediment yields with Nash-Sutcliffe efficiencies always greater than 0.5 and often greater than 0.7. The model's performance was less consistent in simulating the low sediment yields from the no-till plots. The model was then applied to the 30,040 km2 headwaters of the Wei River, a tributary of the Yellow River in China to predict the effects of bench terraces on surface runoff, and sediment transport. The development and incorporation of the terraces algorithm provides a process-based alternative to the use of the P-factor and allows for predictions of multiple effects of terraces on runoff, sediment and nutrient transport, and groundwater recharge.

Can SWAT capture stream flow variability in a semi-arid climate? An application in Muttama catchment, Australia

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Abstract

Seasonal high and low flows are a focus point for catchment managers in Australia, due to the link to drought, floods and water quality. However, the prediction of such flows is highly challenging due to the complex nature of flows (extremely low and very high) along with the variation of geological and geomorphological features. In this study, daily flow estimations for Muttama Creek, located in south eastern of New South Wales, were evaluated using a hydrological model (SWAT). The model was setup using readily available climatic data and landscape information. It was calibrated for 1995 – 2000 and validated against 2006 – 2012. These periods were selected as they include both wet and dry periods. Sequential Uncertainty Fitting-2 (SUFI-2) algorithm was used for the calibration. The Model was evaluated for different objective functions. Initial application of the SWAT shows it can accurately predict stream flows at annual and monthly time scales [NSE annual= 0.93, NSE month = 0.91]. However, at daily scale the stream flow was less well predicted. A plausible reason is the model's inability to properly account for the interaction between the surface and ground water, yielding incorrect simulation of the long term prediction of low flows. The potential of the SWAT model is huge due to its semi-distributed nature and its application to un-gauged basins with wide availability of satellite data, but its success in Australian climate will rely heavily on the proper assessment of the flows during dry and wet periods.

Keywords

SWAT, Low flows, High flows, NSE.

Evaluation of small watersheds inflowing Lake Shinji against the water environment

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Abstract

In our previous study, the Hii River, where contributes approximately 80% of the discharge flowing into Lake Shinji, was selected as a target watershed with a focus on land uses such as paddy fields, upland fields, residential areas, and forestry. Then we figured out that yields per unit area of SS, TN, and TP from upland areas were the greatest, whereas yields from forests were the lowest. However, forests were the largest contributor of them in the basin, because of its dominant land area. At that time, we dealt with forest as mixed forest in the analysis because of land use GIS data set that we used. Thus, we focused on forest this time and improved the GIS data set from one category of mixed forest to six categories of natural and artificial broadleaf forests, natural and artificial coniferous forests, mixed forest, and others. Also we focused on small watersheds around the lake along with Hii River basin to evaluate its influences against the water environment. Moreover, input data sets such as DEM, Soil, the number of weather station location, point source were improved for the analysis. Parameter values were calibrated at the outlet of the Hii River basin because of no observed data in small watersheds. As a result, SWAT could simulate fluctuations of discharge following precipitation pattern relatively well. But parameter values still need to be calibrated to get more accurate results for considering influence of small watersheds, and an impact of the watershed management, especially in artificial forest, against the lake water environment.

Keywords

Hydrology, Land use, Brackish lake

Procedure of hydrological modeling in a semi-arid river basin with SWAT

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Abstract

Water resources availability in the arid and semi arid areas of Iran has experienced reduction because of extremely water usage and drought. Due to fragile ecosystems in arid and semi arid region, the decline in water resources both surface and groundwater lead to environmental challenge in these regions. Successful management of these resources needs to accurate knowledge of the resource available. Although due to lack of suitable data the hydrological modeling and calibration of models in these regions are more difficult than other areas, in this study we tried to estimate freshwater availability at the subbasin level and monthly interval. For this aim, we used soil and water assessment tools (SWAT) to build a hydrological and crop model of the region. Sufi-2 was used to calibrate and validate the model at the sub basin level based on observed discharge and annual winter wheat yields. Nash-Suttclife efficiency (NSE) for discharge and mean square error (MSE) for crop yield were used as objective functions. As a result, the dynamic of river discharge was calibrated pretty well but the pick of events in some month was not captured ideally. Also the crop yields were calibrated pretty well with MSE's objective function in SUFI-2. The low river flows may be is one of the reasons for low P-factor and large R-factor in some hydrometric stations. The results also show that the hydrological process was mainly controlled by soil, deep aquifer recharge and CN2 parameters. Finally, the spatial distribution of water components was mapped and the potential of lands was determined.

Re-conceptualizing the Soil Moisture Accounting of CN-based Runoff Estimation Method in SWAT

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Abstract

Surface runoff estimation in SWAT model is based on the SCS Curve Number (CN) method, with an option of choosing either a soil moisture-based or plant evapotranspiration-based approach. The current application of CN method in SWAT does not accommodate the antecedent soil moisture storage directly into the runoff formulation, thereby leaving the implicit soil moisture accounting (SMA) of the original CN method unutilized. Moreover, within a continuous watershed model, runoff estimation method should be valid not only at the end of a storm but also at any instant during the storm; also, the fraction of rainfall getting transformed into runoff should depend on the current moisture condition of soil profile along with the initial condition resulted from previous modeling time-step. To address these issues, the CN method in SWAT is modified by deriving runoff volume as a derivative of time, with incorporation of four concurrent initial conditions based on a soil moisture storage threshold for runoff to occur. Both the modified and the default SWAT models are tested over two U.S. watersheds having different landuse characteristics. The HRU-level hydrologic outputs such as the soil moisture content, ground water component and surface runoff from the modified CN method are found to be lower compared to those from the current method invariably for urban and forested areas; whereas model outputs are identical for the agricultural area. The modified CN method also underestimates the total streamflow both at high and low flow conditions.

Using SWAT for simulating trade-offs and synergies among ecosystem services related to afforestation in a Central German River Basin

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Abstract

The afforestation program of the German State of Saxony foresees an increase of the forest area from currently 28 to 30%. Increasing the provisioning of certain ecosystem services is one motivation behind this goal. Land owners are even promoted with subsidies to afforest their land. Meanwhile suitable areas for afforestation have to be identified and later on managed by landscape planners and forest districts. The challenge is to simultaneously arrange land use in a sustainable and profitable manner, i.e. under consideration of the related trade-offs and synergies of and among multiple ecosystem services. Hence, the main objective of this study is the quantification of the impact of afforestation on several ecosystem services simultaneously.

The current study is carried out in the Mulde river basin (6,000 km²) which is located in Central Germany. We interviewed five relevant stakeholders to identify i) the importance of suggested ecosystem services, ii) pros and cons of current policies and iii) regional characteristics and potential conflicts for the suggested ecosystem services. Based on ecosystem service outputs provided by SWAT and interview results we analyze afforestation effects on the following ecosystem services: food, bioenergy (both as crop yields) and timber provisioning, water regulation and water quality regulation.

We use the results of this analysis to evaluate the effects of the implemented afforestation program and the corresponding landscape planning management from different perspectives, e.g. stakeholder perception on affected ecosystem services vs. SWAT simulation results, stakeholder perception on afforestation efficiency vs. SWAT simulation results, official afforestation target ecosystem services vs. affected ecosystem services detected by the SWAT simulations. These results provide the basis for a subsequent land use optimization study. Therewith, trade-offs and synergies of and among the studied ecosystem services can be identified by optimizing the land use in the river basin for all ecosystem services simultaneously. Hence, we expect an improved understanding of trade-offs and synergies of and amongst those ecosystem services. This knowledge can help to minimize unintended trade-offs and natural resources impairments and thus support landscape and water management strategies working with the ecosystem services concept.

A hydro-ecological assessment method for temporary rivers. The Candelaro river case study (SE, Italy)

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Abstract

This paper presents the results of a study which characterizes the hydrological regime of a temporary river at reach scale and analyzes the hydrological alterations due to anthropogenic pressures, using the SWAT model to estimate the daily streamflows which would occur in natural conditions. The study area is the Candelaro river basin (2200 km^2), located in SE Italy. We identified five classes of flow (Aquatic States), which play a major role in determining the available mesohabitats and subsequently the characteristics of the aquatic life. The monthly occurrence of the different aquatic states over a long period (10-25 years) has been evaluated in order to provide useful information to design biological samplings. The results show that dry bed conditions can occur from May to January and arheic states (disconnected pools) from April to January in the river sections located in the upper part of the basin. The impacted river reaches showed a different behavior according to the anthropogenic impacts. Two indicators were used, monthly flow permanence and dry season predictability, for describing the flow regime components which may have been altered by anthropogenic pressures. The indexes, which are computed in impacted and natural conditions for each reach, were used as coordinate in a plot to obtain a graphical vision of the regime. The distance between the points representing the actual (impacted) and natural state in the plot were used to classify the hydrological alterations..

Keywords

Temporary rivers, hydrological regime, SWAT model, natural streamflow, hydrological status.

Usage of Biofuel to Mitigate the Current Environmental Impact of Aviation

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Abstract

Aviation biofuel is a biofuel used for aircraft. Aviation biofuel is widely considered by the aviation industry to be one of the primary means by which the industry can reduce its carbon footprint. To Overcome the problems of fuel scarce and rapid increase in fuel cost and also to reduce increasing air pollution due to larger number of Civilian Aircrafts, more improvements have been made by using Bio-fuel blend 20 i.e., purified Jatropha seed oil 20% by volume and Jet A 80%-(HIGHLY PURIFIED KEROSENSE) by volume mixture) for Turbine powered Engines; and the results obtained were good due to significant environmental and economic benefits.

The fuel mixture blend 20 reduces the emissions by Carbon dioxide(80% compared to Jet A), Water Vapour(H_2O),Nitric Oxide(NO) and Nitrogen Oxide(NO_2) which together called as acid rain) etc.,It can extend the life of Turbine engine and also be used as a fuel lubricity additive in Jet A fuel. It results in a slight drop in fuel economy. It can be used in any turbine engines of aircraft and no modification to the engine and fuel system. It is an alternative fuel and provides a domestic renewable energy supply. Jatropha, one source of Potential biofuels, estimated using it could reduce greenhouse gas emissions by up to 85%. The most effective way to decrease a carbon footprint is to decrease the dependence on carbon emitting fuels and to increase the dependence on biofuels. It is found that renewable energy supply fuels is responsible for less Co_2 than fossil fuel generation.

Backward application of SWAT model to assess the impact of agricultural practices changes in water quality

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Abstract

The study area (53 km^2) is the Alegria river watershed, located in the Basque Country (Northern Spain). It is strongly influenced by an alluvial aquifer which due to the agricultural practices applied from the 1980s suffers nitrate-related problems. The area is declared as Nitrate Vulnerable Zone and so it is quite regulated (Code of Good Practices, Actuation Plan, Sectoral Plan of Sugar Beet). One of the objectives of this investigation is using SWAT model (Soil Water Assessment Tool) to simulate for long term (1990-2011) the effect of the regulations input on the water quality.

Discharge and nitrogen load have been satisfactorily simulated at the outlet of the watershed, and so nitrogen fluxes and crop yield. Due to the scattered field measured data, LOADEST program was used in order to obtain daily N-NO_3 load series to which compare the simulated data. Results show that annual N inputs exceed the outputs during all the study period. N surplus decreased from years 1990-1999 to 2000-2008 due to a lower N input in the latter, whereas outputs were quite similar in both periods. From the period 2000-2008 to 2009-2011 the N surplus increased. Although the N input was also lower in the latter, outputs decreased considerably linked to the low precipitation registered during the period.

Keywords

Nitrogen, SWAT, Soil N budget, Long term simulation

Extraction and re-implementation of SWAT-Model calculations under the MAELIA platform in order to simulate the socio-environmental impacts of norms

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Abstract

MAELIA (Multi-Agent for EnvironmentaL norms Impact Assesment) is an agent-based simulation platform designed to assess the impact of alternative water management policies in the Adour-Garonne watershed (France). It simulates interactions between human activities (agricultural, domestic and industrial withdrawals, regulations of water uses) and ecological processes (crop growth, plant evapotranspiration and water flow). In MAELIA to precisely simulate the water cycles at the sub-watershed level the representations of hydrological processes in SWAT were analysed and re-implemented.

In this paper, we discussed some of the design choices and simplifications we first made in order to integrate the following SWAT formalisms: surface-runoff, lateral-flow, base flow and evapotranspiration on the land phase and the water-routing, transmission losses and its return flow on the routing phase. For the purpose of specifying and implementing these processes in the platform, we mainly referred to the SWAT Theoretical andInput/output File Documentations, as well as the Fortran-90 source code. Given the specificities of MAELIA in terms of representation of sub-watersheds and HRUs (provided by specific European and French databases like The French “Land Parcel Identification System”), we adapted the way to build and represent these entities.Furthermore, we developed a MAELIA project into ArcSWAT/SWAT. This enables us (i) to compare outputs of the two platforms (MAELIA vs. SWAT) to ensure quality of implementation of SWAT formalisms and (ii) to use features of SWAT for estimation of parameters and input values that are use, directly or after adaptation, in the MAELIA platform. We apply and present results of both platforms in the upstream part of the Adour-Garonne basin for a 10-years period (1999-2009).

Keywords

SWAT, re-implementation, agent-based socio-environmental simulation platform

Water management modeling in SWIM: new features and applications

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Abstract

Climate change and land-use change impact studies in managed river basins require an adequate representation of both natural processes and those influenced by land and water management. As most large river basins today are affected by human intervention and regulation these management practices need to be considered in (eco)hydrological models.

A reservoir module developed by Koch et al. (2013) for SWIM is used to investigate the impacts of reservoir management strategies and construction of new dams on river discharge, and to estimate the generation of hydropower. The module implements three management options:

i. variable daily minimum discharge to meet discharge targets, e.g. environmental flow, downstream under consideration of maximum and minimum water levels in the reservoir;
ii. daily release based on firm energy yield by a hydropower plant at the reservoir (the release to produce the required energy is calculated depending on the water level);
iii. daily release depending on water level (rising/falling release with increased/lowered water level, depending on the objective of reservoir management).

Also withdrawals, e.g. for agricultural irrigation, can be included in the reservoir module.

The module can be applied to rather small dams with a simple management approach or huge reservoirs with highly sophisticated management rules. Examples from Africa (Nile, Niger, Limpopo) and South America (Sao Francisco) are presented. Problems and future work are discussed.

SWATing your APEX model: a how-to from the trenches

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Abstract

Methodologies to link edge-of-field observations to stream loadings need to be developed to integrate what we know of soil and water quality at the field scale to watersheds and river basins. The Soil and Water Assessment Tool (SWAT) can be used to scale up results obtained at field scale with the Agricultural Policy Environmental eXtender (APEX). The APEX and SWAT models are particularly well adapted to this integration because they belong to the same family of models and have many common input parameters. However, they are not identical and the differences need to be recognized before both models can be used jointly. For example, while runoff can be calculated with the Curve Number method in both models, soil moisture routing is different and lead to different soil water content values that affect the curve number, and thus runoff. Similarly, both models can use the MUSLE equation to calculate sediment loss but the soil cover factor is calculated using two very different concepts. This paper reviews the differences in algorithm and parameterization between APEX and SWAT. Since APEX parameterization is more flexible, we define how it can be parameterized so that it becomes equivalent to SWAT, whenever possible. The analysis will help model users separate the model effects from true scale effects when parameterizing these models and interpreting their results.

Streamflow modeling in a highly managed complex watershed

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Abstract

Streamflow simulation in mountainous watersheds is a challenging task because of the complex topography and singular hydrological processes (e.g. precipitation and temperature altitude gradients etc). Anthropogenic influences like water storage for hydropower, changes the regime of river on a seasonal basis. We simulate streamflow in the upper Rhone river watershed (Switzerland) where 11 high head hydropower storage reservoir and frequent water transfer occurs. This water transfer alters the regular hydrological regime increasing the flow in winter and decreasing the flow in summer. The network configuration was done implementing all the capture points and routing of water according to the operation of reservoirs. Both manual and automatic calibration were performed, and parameter sensitivity reveals the most sensitive parameters are linked with snow and glacier melt process. A decent performance statistics were obtained after calibration [NSE=0.69, R^2=0.81, PBIAS=6.7]. Our study suggests that process implementation is more important than parameter optimization for anthropogenic-disturbed watersheds. Information obtained from this study can be useful applying SWAT model in the similar hydro physiographic condition.

Keywords

SWAT, Snowmelt, Hydropower reservoir, Water transfer.

Estimation of sediment yield in an agriculture - forest dominated non-conservative watershed with SWAT model

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Abstract

Soil erosion is an immense problem that has threatened soil and water conservation in the world. The objective of this study is to estimate the sediment yield at the main outlet of an agriculture - forest dominated and non-conservative watershed which receives external groundwater (EXT). Shibetsu River watershed (SRW, 672 km^2) located in Hokkaido, Japan was selected in this study. Soil and water assessment tool (SWAT) modified with EXT (SWAT-EXT) was used to estimate sediment yield in SRW. EXT (1.38 mm day^{-1}) was added into each hydrological response unit (HRU) to account its contribution to stream. Daily sediment yield was calibrated from 2003 to 2004 and validated in 2007 with observed values. Performance of the SWAT-EXT was evaluated by R^2, Nash and Sutcliffe efficiency coefficient (E_{NS}) and relative error (Re). Comparison between measured and simulated daily sediment yield showed a strong agreement, which yielded R^2 of 0.56 and E_{NS} of 0.53 in calibration period and R^2 of 0.70 and E_{NS} of 0.49 in validation period. SWAT-EXT simulated annual sediment yield was 19154 tons which was close to observed value of 21560 tons with Re of 11%. However, using same fitted parameters, original SWAT model without taking EXT into account simulated annual sediment yield of 10707 tons, which underestimated sediment yield with relative error of 50% and indicated EXT increased sediment export to the seashore. Mean annual landscape erosion was estimated as 55034 tons. Sub-watersheds with steep slope of more than 10 degrees were the critical source of landscape erosion. Annual sediment yield at the outlet of SRW accounted for 39.2% of the landscape erosion. These suggested that channel sedimentation associated with landscape erosion happened in SRW. Second and third order streams were estimated as places for channel sedimentation, but main stream was identified as the place for channel erosion. SWAT-EXT was an appropriate tool for sediment yield estimation and understanding soil erosion mechanisms in SRW.

Adapting SWAT model for the evaluation of water harvesting systems in an arid environment: a case from Jordan

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Abstract

Water scarcity and land degradation are widespread problems that affect agricultural productivity, food security and environmental quality in several parts of the world, particularly in the dry areas. Sustainable management of soil and water is necessary to optimize the use of limited rainwater for crop production and to decrease soil erosion. One management option is utilizing rainfall more efficiently through water harvesting. In arid areas, different types of water harvesting techniques (WHT) are being developed by researchers and used by farmers to utilize runoff water and to enhance plant growth. However, the effect of water harvesting on the reduction of soil erosion and runoff is not adequately known.

This study aims at adapting the SWAT model to predict the impacts of selected water harvesting interventions on the bio-physical and hydrological processes and to evaluate their application in arid environments. Four sites, representing small sub-watersheds (hill slopes) were selected for modeling purposes in Al-Majidyya village 40 km south-east of Amman, which represents an arid area of Jordan (known locally as Al-Badia). The average annual rainfall in this area is less than 150 mm. Two small sub-watersheds (paired swales) were selected to measure runoff and erosion, using flow meters and ISCO automatic samplers. One of these swales has been treated using Vallerani plough to form intermittent pits to collect and store runoff water. This swale was planted by Salsola vermiculata shrubs and the other swale has been left without any intervention (control representing the natural rangelands in the area). The other two small sub-watersheds (paired swales) were selected to measure sediment yield only using geo-textile trap. One of these paired swales contains continuous contour ridges as water harvesting measure and was planted with Atriplex halimus shrubs while the other sub-watershed was left without intervention and planted with Barley (*Hordeum vulgare*), representing the farmer practices.

The model input parameters were derived using the SWAT ArcGIS Interface. Some parameters (Leaf Area Index and Harvest Index) for plant growth were modified to suit the prevailing arid conditions in the watersheds. Many iterations were carried out by introducing different management options in SWAT databases taking into account the subbasin, HRU and curve number values. The model overestimated the runoff and sediment yield from the water harvesting sites and to large extent accurately estimated for the sites without interventions. For example, the sediment yield predicted for the continuous contour ridges for a selected storm was 0.09 t/ha whereas no sediments were observed in the field. The predicted sediment yield for the barley site was 0.55 t/ha and the observed value was 0.34 t/ha.

Manual calibration/comparisons for measured and observed results are needed to adapt the model for this arid environment and to accurately estimate the effect of water harvesting interventions. In addition the comparison of biomass and crop yield will also be analyzed between observed and SWAT predicted outputs.

Keywords

Soil and water losses, soil conservation, land degradation, rangelands

Assessment of nitrogen retention in the Seine river basin by different approaches

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Abstract

The assessment of nitrogen retention in large river system is complex due to the dependency on climate, hydrological and physical characteristics. Measurements are generally limited in number and do not represent the full integration of all the processes contributing to nitrogen retention in the river basin. However, the estimation of nitrogen retention is crucial to understand the water pollution and the N2O emissions to the atmosphere, as well as the lag time between the implementation of agri-environmental measures to reduce nitrogen pollution and the improvement of water quality. Models have often been used to overcome the lack of information and to understand the dynamic of the river basin system. The objective of this study is to assess the nitrogen retention in the Seine river basin (76700 km2, in France) by the application of three models of different complexity and developed for different specific purposes: GREEN, SWAT and RiverStralher. The study analyses the different modelling approaches and compares their estimates of nitrogen retention over a period of 10 years. The research shows the potential and limitation of the three approaches for assessing nitrogen retention. The results of this study are relevant for the understanding of nitrogen retention process at large river basin scale and for the analysis of scenarios of mitigation measure to reduce nitrogen impacts on the aquatic ecosystem and the climate.

Soil-landscape modeling to predict the spatial distribution of soil attributes for environmental applications

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Abstract

The spatial distribution of surface and subsurface soil attributes is an important input to environmental modeling. An ArcGIS based user-friendly model was developed to predict soil attributes using soil-landscape relationships. The essential inputs are digital elevation model and field observations where soil attributes are measured. Additional layers, such as satellite images and auxiliary data, improve the prediction accuracy. The model contains a series of steps using menu-driven system, which allow the users to choose between different methods and to run several iterations to achieve acceptable results. The steps are summarized in deriving many terrain attributes to characterize each pixel based on local attributes (slope, aspect, curvature, and others) and based on the characteristics of the pixels located above that pixel in the same topo-sequece (flow accumulation; compound topographic index; average slope, aspect and curvature of the contributing area). The model then subdivide the whole watershed into smaller facets, each facet is one sub-watershed divided by the stream line. The facets are classified into number of classes to allow sufficient number of observations to be retained within each class. A linear regression model to predict soil attributes from terrain attributes and auxiliary data are established for each class. These regressions are applied for each pixel within each class to provide continuous surface of soil attributes for the whole watershed. The accuracy of these predictions was tested against soil observations and indicated acceptable accuracy. Furthermore, the predicted layers of soil attributes can be used to develop SWAT and other similar models to evaluate water and environmental resources. A case study of SWAT model application in a small watershed in Tana basin in Eithiopia is presented. The model is public domain and will be available within SWAT for researchers to evaluate.

Keywords

GIS, remote sensing, terrain attributes, auxiliary data, spatial analysis

Swat Owl: A new tool for quicker visualisation of SWAT outputs and calibration

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Abstract

Swat Owl is a new suite of tools which has been developed to allow SWAT modellers to see snapshots of model outputs. The tool runs as a stand-alone executable file and speedily produces graphical outputs, summaries of water balance data, and calibration statistics. The user can switch between saved model runs to compare the effect of changes to parameters on the water balances and calibrations. The tools have been developed as part of an ongoing project to model 23 surface water catchments for Anglian Water (East of England).

Swat Owl comprises the following tools (i) snapshot of average annual water balance (ii) average monthly water balance charts for entire model (iii) graphs showing a wide selection of parameters output at HRU level (iv) graphical output of flow data for all the reaches and subbasins on one page (v) graphical output of observed and modelled flows with built-in baseflow calculation, Nash Sutcliffe calculations, and other statistics. (vi) a scripting tool to automatically run SQL 'Update' queries, re-write SWAT input files, run the model, save the results and statistics, and log the changes.

The aim of the paper is to demonstrate the tool to a wider audience and to demonstrate how rapid visualisation of water balance outputs can lead to better understanding of how parameters influence the flow paths within SWAT leading to faster calibration and better representation of catchment flows. Feedback on the usefulness of the tool will be invited.

Keywords

SWAT, Postprocessor, Calibration Statistics, Water Balance Summary, SQL Updates, Graphical Output, Baseflow Calculation.

Integration of SWAT into a real-time web-based DS tool for sugarcane irrigation management

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Abstract

Soil and Water Assessment Tool (SWAT) is a process-based model for simulating hydrology and water quality in a watershed running at daily time interval. A real-time decision support (DS) tool was built around the SWAT model for sugarcane irrigation management in Hawaii. Hawaiian Commercial & Sugarcane Company (HC&S) consumes 270 million gallons of water every day on its 14,100-hectare plantation, among which 71 % is rainforest water irrigated from rainforests via 76 miles of ditches and tunnels while the remaining 29 % is supplemental ground water. It has been recognized by HC&S that the availability of water is the most critical factor that affects sustainability of Maui's sugar production. The real-time DS tool is built as a web application based on ASP.net framework with secure access to a SQL Server database and the SWAT model. This paper/presentation focuses on the technical aspects of the development. Data flow between SWAT, SQL server, and web application will be presented. Challenges in (1) constructing a SWAT model for arbitrarily shaped sugarcane plantation fields and plots, (2) calibrating the SWAT model in this data-scarce modeling environment, and (3) coupling a real-time database model with SWAT, a DOS-command continuous simulation model, will be discussed.

SWAT applications in Brazil: A survey of the past 10 years

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Abstract

In Brazil, the hydrological model SWAT (Soil and Water Assessment Tool) has been used to evaluate many different hydrological conditions. The SWAT model has also been implemented among many different institutions and countries worldwide. This study aims to identify, map, and discuss the use of the SWAT model in Brazil. This paper will include scientific evidence from more than 100 papers, and information from thesis's and dissertations that applied the SWAT model in the past 10 years in Brazil. Most of the applications were in watersheds from the South and Southeast of Brazil (79%) and the rest of the applications (21%) were in the Northeast and Midwest of Brazil. The publications cover various areas of application of the model (water balance, hydrology, water quality, climate and land use changes, soil and agricultural management and sediment production). Despite the diversity regarding climatic and hydrological conditions in the different regions of Brazil, the studies regarding SWAT have indicated a good performance. You can infer from the results published on the use of SWAT in Brazil that the tool serves as a decision support for businesses and government agencies. There are many academic studies; however, there are very few reports on the practical use of SWAT in Brazil. This deficiency is most likely related to the difficulty in obtaining data, with sufficient quantity and quality, to simulate the processes of a watershed in SWAT.

Keywords

Review paper, SWAT, Brazil, Applications

An Integrated Modeling System for Simulating Export of Nutrient Loads from the U.S. Corn Belt Region to the Gulf of Mexico

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Abstract

An extensive seasonal hypoxic zone has formed in the Northern Gulf of Mexico since the mid-1980s due to nitrogen (N) and phosphorus (P) loads discharged from the Mississippi-Atchafalaya River Basin (MARB). The Upper Mississippi River Basin (UMRB) and Ohio River Basin (OTRB) stream systems are the major MARB N and P source regions, primarily via nutrient export from agricultural landscapes. We have constructed an integrated modeling system that will: (1) estimate nutrient loads from the UMRB and ORTB regions for different scenarios, (2) route the estimated nutrient loads for each scenario to the Gulf of Mexico, and (3) input each set of nutrient loads into a hypoxic zone model to predict the resultant size of the seasonal hypoxic zone. The Soil and Water Assessment Tool (SWAT) model is being used to simulate the URMB and ORTB land management schemes and resultant nutrient loads to the Gulf of Mexico. Optimal placement of cropping/management systems on specific landscapes within SWAT can be via an interface with an evolutionary algorithm (EA) and corresponding cost data for each management system. A regression model is used to estimate hypoxic zone size as a function of nutrient fluxes discharged from the Mississippi River and other relevant data. A description of the entire system will be presented, with particular emphasis on the SWAT component of the modeling system including a detailed grid for input of Global Climate Model (GCM) projection data. Baseline testing and representative scenarios are described in a companion study by Panagopoulos et al.

The Effect of Nutrient Reduction Practices on Water Quality of the Large Corn Belt River Basin Systems under Existing and Future Climate

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Abstract

Agricultural nonpoint source pollution is the main source of nutrients in the intensely row-cropped Upper Mississippi River Basin (UMRB) and Ohio-Tennessee River Basin (OTRB) stream systems, and is considered the primary cause of the Northern Gulf of Mexico hypoxic zone according to the US Environmental Protection Agency. Thus, process-based models such as SWAT can play a crucial role in estimating river basin responses to water pollution mitigation practices under the current and future climate. An integrated modeling system has been constructed with the Soil and Water Assessment Tool (SWAT) model, capable of estimating river basin responses to alternative cropping and/or management strategies, simulated at thousands of HRUs using a greatly refined subwatershed schematization (as described in the companion presentation by Gassman et al). The purpose of this study is first to present the challenging task of calibration of the large and spatially detailed UMRB and OTRB modeling studies with the use of the Sequential Uncertainty Fitting algorithm (SUFI-2) and the SWAT-CUP interface. The calibration framework provides estimates of the uncertainty of predictions at various locations and can be finalized within a reasonable timeframe with a powerful personal computer (PC). Then, possible nutrient reduction practices recommended under the USEPA's policy framework for managing nutrient pollution will be presented and discussed including: nutrient application strategies, cover crops, perennial energy crops, extended rotations and tillage methods. Emphasis will be given on the performance and viability of these practices under a climate change scenario compared to the existing climatic conditions.

Climate Change Vulnerability in the Black Sea Catchment

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Abstract

Agriculture in the Black Sea catchment is responsible for a considerable share of the area's total water withdrawal and the majority of its total water consumption. It therefore plays a key role in sustainable water resources management. However, in the future water resources might be threatened considerably due to climate change. Precipitation and temperature changes will not only modify water availability for rainfed agriculture, but will also impact irrigation capacity.

This vulnerability assessment aims to identify the most vulnerable regions and to explain why these regions are considered to be vulnerable. The assessment framework is based on a combination of the DPSIR framework and the vulnerability concept as defined by the IPCC. Three different climate change scenarios are used for the assessment: 1) An increase in temperature; 2) A decrease in precipitation; and 3) A combination of the first and second scenarios. The data for this assessment is derived from a SWAT model that has been set up in the enviroGRIDS project.

The results show that the regions of the Black Sea catchment are impacted by climate change differently. Some countries benefit from climate change, while others encounter considerably worse agro-climatic conditions in future. Notably, Turkey experiences severe water stress, whereas mountainous regions benefit the most from higher temperatures. Additionally, natural plant growth conditions mostly improve due to more suitable temperature conditions. In contrast, the deteriorating agricultural conditions mainly result from a diminishing irrigation potential that is caused by reduced precipitation.

Effects of elevation bands and snow parameters on the hydrological modeling of the upper part of the Garonne watershed (France)

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Abstract

The hydrological modeling of mountainous area can be problematic, mainly due to the changes in precipitation and temperature with elevation. The Soil and Water Assessment Tool (SWAT) is developed for large agricultural watersheds. Several studies indicated that good results can be obtained for the mountainous regions when using elevation band and snow parameters. However, few studies considered the functions of the elevation bands and snow fall-melting on the large catchments including just a small part of mountainous areas. The Garonne river watershed is located in the southwest of France, with an area of about 51500 km^2 and mountains higher than 2000 meters covering about 12% of the total area. The hydrology of the Garonne river was simulated with SWAT model and compared with the monthly discharge recorded on six gauging stations in the upper part of the catchment upstream Toulouse city. The results show that the correlation without taking into account elevation band and snow gave an R^2 of 0.57. When changing snow parameters, the results were not improved significantly (R^2 = 0.60), however, when adding the elevation bands, the correlation was better with an R^2 increasing from 0.57 to 0.64. The comparison of the simulations with the six gauging station illustrated that the impact of elevation bands is bigger than snow, but the best result was found after the modifications of both parts (R^2 = 0.70). However the effects on hydrology became less marked as the distance to the mountains increase.

Keywords

Garonne, SWAT, elevation band, snow, mountain, modeling, hydrology.

Assessing the Implications of Water Harvesting Intensification on Upstream-Downstream Social-Ecological Resilience: A case study in the Lake Tana Basin

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Abstract

Droughts and dry spells are among the major factors for famine and environmental degradation in sub-Saharan Africa. Field research has shown that water harvesting practices can reduce crop failures and also improve agricultural yields. Sub-Saharan Africa is considered to have enormous potential for water harvesting implementations. For example, our studies in the Upper Blue Nile Basin demonstrated that large part of the Upper Blue Nile Basin is suitable for water harvesting. However, little research is performed to investigate the implications of large scale water harvesting implementations on upstream-downstream social-ecological resilience at a meso-scale basin. In this research, we will study the implications of intensifying water harvesting on upstream-downstream social-ecological resilience in case study in one of the subbasins in the Lake Tana basin. The Soil and Water Assessment Tool (SWAT) is setup, and calibrated at three river gauging stations (i.e. Gilgel Abay, Gumera, and Megech). Nash-Sutcliff efficiency of more than 0.7 is found in each of the gauging stations. One of the subbasins in Megech watershed is chosen for detailed investigation of the consequences water harvesting on the upstream-downstream social-ecological systems. This subbasin will be further subdivsied into finer scale subbasins so that ponds will be implemented (over suitable subbasins) for water harvesting. Irrigation for vegetable cropping will be applied from ponds. Consequently, the change in water balance, sediment transport, and crop yield before and after water harvesting implementation will be investigated. Moreover, the implications of these bio-physical changes on the social-ecological systems will be explored.

Using SWAT model to assess different land use scenarios impact on streamflow in Fuhe Watershed, China

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Abstract

In order to understand hydrology regime and water resources, in the Fuhe watershed (Poyang Lake basin, East China), SWAT (Soil and Water Assessment Tool) model was used to simulate the hydrological processes under different land cover scenarios. Land use classification map was classified into 8 classes:15.1% agricultural land-close-grown,8.43% agricultural land-row crops,60.63% forest,9.08% pasture,3.49% urban,1.16% water,0.25% wetland,1.8% bare land and then different land use scenarios were set to compare the capacity of preventing the water and soil erosion between agricultural land, forest and bare land.

A total of 12 model parameters were calibrated with observed monthly runoff data for 2000-2004 and validated for 2005-2007.the coefficient of determination of linear regression (R^2) were higher than 0.75 and the corresponding Nash-Sutcliffe Index(NSI)values of Lijiadu hydrological station(the outlet of Fuhe watershed) were all above 0.75.The results showed that the SWAT model presented a good simulation on the hydrological processes of the Fuhe watershed. Compared with the existing land use conditions, predicted runoff decreased 10.6% with 301m3/s monthly when all the agricultural land(3477km2) was changed into forest land; runoff decreased 6.63% with 314m3/s when all the agricultural land area changed into pasture land ;runoff increased 9.2% with 368m3/s when all the forest and grass land area(10302km2) changed into bare land. When all the forest and grass land area changed into agricultural land, the runoff reached to 353m3/s, increased 4.86%.Scenario simulation suggested that runoff dropped under increasing forest land and grassland areas and decreasing paddy field and urban areas. This result proves that forest land have better ability to hold back the water than pasture land and agricultural land is better than bare land to prevent the soil erosion which results the runoff increase.

Keywords

SWAT; runoff; Poyang Lake; Fuhe watershed; simulation

Influence of evapotranspiration estimates on the water balance of sugarcane cropping system in the Hawaiian island of Maui

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Abstract

Under Hawaiian tropical weather conditions, evapotranspiration (ET) is the primary mechanism by which water is removed from natural and agricultural systems. Accurate estimation of ET provides a valuable insight to better determine crop water requirement in order to maximize crop yield and water use efficiency. The year-long warm temperature and other climatic characteristics of the Pacific Ocean Islands have made Hawaii an ideal place for growing sugarcane. For this reason, Maui's Hawaiian Commercial and Sugar (HC&S) company, the largest sugarcane grower of Hawaiian Islands, has developed a locally optimized ET equation for its water management purposes. Using the Soil Water Assessment Tool (SWAT) and historical weather data, the performance of the HC&S method was compared with three physically-based methods: Penman-Monteith, Priestley-Taylor, and Hargreaves to assess the influence of ET on the hydrological water balance of the HC&S' sugarcane cropping system. The SWAT project was setup to represent a 2-year sugarcane crop system for the period between 2003 and 2012. In order to assure correct partitioning of water balance components, simulated sugarcane yield was calibrated using historical data. In addition, canopy development was also calibrated to the local crop development curve by adjusting the SWAT's parameters related to the leaf area development. The results indicate that the four methods within SWAT produced different hydrologic water balance predictions. However, the evapotranspiration estimates by all methods shows the same trend throughout the year. Additionally, results show that wind velocity is the most influential factor over ET in the Hawaiian sugarcane fields. These findings can be used to improve the irrigation efficiency as well as other management scenarios to optimize water use in the island of Maui.

Using SWAT model to characterize flow influence on the Pyrenean desman *(Galemys pyrenaicus)*

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Abstract

The Pyrenean desman (Galemys pyrenaicus) is a small semi-aquatic mammal restricted to the Pyrenees (Andorra, France and Spain), as well as parts of northern and central Spain and northern Portugal. It lives in mountain brooks, cold and well oxygenated water courses from sea level to 2700 m in the French Pyrenees. Even though there is a lack of knowledge about the biology and ecology of the Pyrenean desman, human activities such as hydraulic river regulation (e.g. hydro-electric dams and reservoir construction) are suspected to be a main cause of the alterations of its habitat leading to its substantial decline.

The SWAT model was used in a sub-catchment of the Ariège basin (France) in the Pyrenees mountains to characterize hydrological parameters of the Desman habitat and understand the influence of these factors on its spatial distribution.

River flow was simulated for 20 years (1992-2011) at fine spatial scale (around 1 km long) and at monthly time scale. Spatial data used to calibrate the SWAT model were a digital elevation model with a 25 m grid and a land-use map carried out by the regional natural park of Ariège. Climate data were obtained from the Meteo France model at 8 km grid resolution. The entire catchment (1156 km^2) was divided into 1165 sub-catchments. Simulations of the river flow were consistent with the observed data measured in five gauging stations, when they were taking into account snow and dams. We then related these hydrological parameters to the distribution of the Pyrenean desman to characterize some habitat requirements of this species and identify the environmental parameters influencing the most its distribution.

Estimation of groundwater recharge by using surface-subsurface hydrological model

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Abstract

The estimation of recharge is essential for the proper management as well as for the protection of groundwater resources. The groundwater models are used to simulate the flow of water in the aquifers; when it is calibrated, it can be used to simulate the long-term behavior of an aquifer. Without a good estimate of recharge and its spatial and temporal distribution, these models are more reliable. In this study, the models SWAT (Soil and Water Assessment Tool) and MODFLOW of GMS (Groundwater Modeling System) are integrated in order to calculate the rate of groundwater recharge, since the SWAT model does not take into consideration distributed parameters such as hydraulic conductivity and storage coefficient. To solve this problem, the characteristics of hydrological response units (HRU) in the SWAT model are exchanged with cells in the MODFLOW model of GMS. Using this interface HRU-cells conversion, the rate of groundwater recharge can be efficiently simulated. This method is applied to the aquifer of R'Mel in Morocco for a more accurate spatio-temporal estimation of groundwater recharge. The application has been tested successfully, and which demonstrates that the integrated model surface water-groundwater (SWAT-MODFLOW) is able to simulate spatial and temporal distribution of the recharge rates of groundwater. This model would be beneficial in the planning and the sustainable management of groundwater.

Keywords

Hydrological Models, SWAT, MODFLOW, Groundwater Recharge, Spatio-Temporal Estimation, Management of Groundwater.

Ephemeral stream runoff analysis by using SWAT-K

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Abstract

In the Jeju Island (Republic of Korea), surface runoff characteristics are very different from those of the inland. Most streams dry up shortly after rainfall events due to the rapid recharge of deep aquifers through highly permeable volcanic basalt rock. Accurate estimation of hydrologic components is very hard. Thus, the process based conceptual-physical scheme is established based on SWAT-K(Korea) and applied to Cheonmi-cheon watershed which shows typical pattern of ephemeral stream runoff characteristics. The intermediate flow and baseflow portion of SWAT-Kare controlled to make downward percolation should be dominant. The surface runoff simulated by using the modified scheme showed good agreement with observed runoff data including short and long term rainfall-runoff relation. This conceptual model is being progressed including rainfall interception, spatially estimated evapotranspiration, snow-melting and so forth for the reasonable simulation of the hydrologic characteristics in Jeju island.

Acknowledgements

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Effects of Changes in Agricultural Irrigation Systems on Surface Water Resources – A SWAT-based Study in South India

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Abstract

Under monsoon-driven climate with a strong seasonality in rainfall, agricultural management is closely linked to water resource management. Hydrological modelling is therefore essential for a sustainable agricultural management, especially if changes in land management and irrigation systems are to be evaluated. The major goal of this study is to analyze the effects of increased groundwater use for irrigation on the surface water resources in a meso-scale catchment in Southern India using the Soil and Water Assessment Tool (SWAT). The examined catchment drains an area of about 5300 km2 and is located upstream of the Krishnagiri reservoir in Tamil Nadu, India. The catchment's topography is more or less plain with sporadic Inselberg outcrops from the Archean granite-gneiss bedrock. The dominant soils of the catchment are Nitisols and Luvisols. The climate is influenced by the southwest and northeast monsoon, leading to high rainfall amounts in May and October, while the highest temperatures are observed in April. The annual rainfall is about 1000 mm. The catchment is traditionally used for intensive, mostly irrigation-based agriculture with rice, millet and peanuts as main cash crops. The traditional irrigation system relies on small surface reservoirs for rainwater harvesting. With increasing groundwater use for irrigation, which results from improvements in technical equipment and public power supply, these reservoir systems are losing their relative importance as agricultural water supply and are partly getting silted due to reduced maintenance. We hypothesize that this shift in irrigation systems has a significant effect on surface water resources, especially on surface runoff peaks and on temporal evaporation patterns. Furthermore we try to assess the effect of these changing conditions towards sustainable water resources management. This evaluation will mainly be based on the likely effects on groundwater resources, while especially incorporating an estimation of groundwater recharge rates.

SWAT application for economic analysis of nutrient and carbon loads

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Abstract

Evaluating the least-cost combination of measures to control organic matter from anthropogenic sources is a challenge which the established modeling tools do not provide solutions for. The MultiDOM project is an interdisciplinary collaboration to clarify the role of terrestrial dissolved organic matter (DOM) in the water quality of the Baltic Sea and to establish a model for cost-efficient control strategy of the load. This study describes the use of soil and water assessment tool (SWAT) in the interdisciplinary project. River Vantaanjoki catchment was chosen as a case study area, which reflects the water quality concerns of the Helsinki metropolitan administration and the recreational value of the river as well as the coast. We apply SWAT to gain more spatial and temporal coverage than the sparse monitoring and sampling network of the study area would provide. Hence, we are able to estimate the quantity and quality of DOM loads to the Baltic Sea from the catchment, describe the effects of land use on quantity and biological degradability of the DOM load and facilitate a Bayesian network study on nutrients. For the cost-efficiency analysis, we find that SWAT is suited to limited scenario analysis, but that the model structure would require modifications for the least-cost combination of land use classes.

Simulation of stream nitrate-nitrogen export using SWAT model in a mesoscale watershed with an external water source in Northern Japan

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Abstract

Quantitative assessment of stream nitrate-nitrogen (NO_3^--N) export in a watershed with an external underground water source is complex because the underground flux both for water discharge and NO_3^-N cannot be directly measured. A modeling approach, using SWAT model driven by detailed field data, was tested to simulate the NO_3^--N export in the 672 km^2 Shibetsu watershed which gains water from the outside watershed in eastern Hokkaido, Japan. The external water source (EXT) and its containing NO_3^--N loading were added as the assumed point source discharge and loading in SWAT model. The results yielded high E_{ns} (Nash-Suttcliffe coefficient) values for daily streamflow (over 0.5) and monthly NO_3^--N loading (over 0.7) simulation during the calibration and validation periods. The simulated seasonal patterns of discharge and NO_3^--N loading also well matched with measured data during 2004 to 2008. However, the spatial patterns of NO_3^--N concentrations showed a poor R^2 correlation (R^2=0.34) with the measured data in 2004. These results show that although the model had limitation to simulate the spatial patterns, the method of adding EXT and NO_3^--N loading in assumed points in SWAT was reasonable to assess the stream NO_3^--N export. Therefore, the calibrated model was repeated without adding EXT and NO_3^--N loading in assumed points. About 66% of NO_3^--N export was from the watershed itself and the NO_3^--N export was high in grassland. The result indicated that most of NO_3^--N export was related to dairy farming in Shibetsu watershed and the best management practice for controlling non-point source pollution should focus on manure application on grassland in the future. Meanwhile, the EXT (47% of streamflow) contributed to 34% of annual NO_3^--N loading, which may cause the overestimation of stream NO_3^--N export by only using the measured data. Therefore, the EXT should not be ignored while estimating the annual NO_3^--N loading.

Comparison of the Penman Monteith and Regional Calibration of Hargreaves Equation for Actual Evapotranspiration using SWAT Simulated Results in Seolma-Cheon 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 73 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 adjusted Hargreaves) of SWAT model by comparing with the measured actual evapotranspiration data in Seolma cheon watershed (8.48km^2). 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 (R^2) of was 0.78. The regional calibration of Hargreaves will be contributed for a better understanding of evapotranspiration an ungauged catchment in areas where meteorological information is scarce.

Keywords

SWAT, Evapotranspiration, Hargreaves equation, Flux data, Regional calibration

Application of the SWAT model for water resource management considering Climate change in Chao Phraya River, Thailand

Han Na Kim, Kyung Hwa Cho, Yongeun Park, Seung Won Lee, Dong Jin Jeon, Joon Ha Kim

Abstract

The Chao Phraya River is a major river in Thailand, with its low alluvial plain forming the central of country. In particular the river basin frequently experienced severe drought and flood due to climate change. The objective of this study is to assess impacts of climate and land-use change on water quality in the Chao Phraya River. The Map Window Soil and Water and Assessment Tool (MWSWAT) was applied to predict stream flow and water quality due to the change of hydrologic characteristics of the watershed, using collected meteorological data and stream flow data for 12-year period from January 1, 2000 to December 31, 2011. Future climate factors (e.g., temperature and precipitation) predicted by a general circulation model (GCM) were used to consider climate change impact in the watershed. The results can play a significant role in developing management scheme for water quality the watershed. This research can be used to make a preliminary assessment of the potential impacts of land use and climate changes.

Keywords

Chao Phraya River, MWSWAT, Climate change

Application of SWAT on upper watershed of river Subarnarekha with special reference to climate and land use changes

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Abstract

The Upper Watershed of River Subarnarekha lies within 23° 10’ to 23° 40’ N and 85° 10’ to 85° 40’ E in the state of Jharkhand, India, with an elevation of 300 mt to 700 mt. The physiography of the upper basin chiefly consists of plateaus, uplands and some flat plains with deposits of red and alluvial soil. The river course consists of gorges and waterfalls with exposed rocks of granite, genesis, pegamatite. The sediment’s erosion and transportation is greatly affected by the sharp meandering of river. The Hundru and Johna waterfalls associated with the river channel have continuously eroded the upper surface of exposed rocks. The encroachment like human settlements, agriculture, illegal sand mining and stone mining has affected the stability of the river banks. The land use changes, especially the conversion of forest area into agricultural land have largely affected the geology of upper watershed. Soil and Water Assessment Tool (SWAT) model, is used in the present study to assess the impact of land use changes and its relation with hydrology of the study area with special consideration of Geomorphological aspects. The SWAT is a physically based continuous time hydrological model with Arc view GIS interface developed by the Blackland Research and Extension Center and the USDA-ARS (Arnold et al., 1998). SWAT model can be easily applied to the large watershed, the output of which can be used for effective study of soil erosion, surface run off, utilization of land for agricultural purpose. This study will help the policy makers, planners to identify and priorities the areas which are affected by sediments erosion and excess run off.

Keywords

Watershed, Land use, Surface run off, Soil erosion, waterfall

Reconstruction of natural streamflow by SWAT modelling

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Abstract

Streamflow time series can be perturbed by dams, reservoirs, diversions, water taking/release from/to stream, groundwater pumping, and urban development, making it difficult for hydrological studies to assess natural trends and variability in runoff. The objectives of this study are to reconstruct natural streamflow using SWAT modeling and to assess the impacts of irrigation reservoir, groundwater withdrawals, sewage disposal release on streamflow in the Bokhacheon basin of South Korea. To this end, SWAT model was revised to reflect the effects of reduction of groundwater discharge due to groundwater withdrawals, blockage of outflow of an irrigation reservoir, and return flow of the used water to stream. The model was calibrated until the simulated and observed streamflows were matched to each other under the current water use conditions. Then the calibrated model was run again without considering current water use/release and irrigation reservoir to obtain the natural streamflow data. The differences between regulated (current) and unregulated (natural) streamflows were demonstrated and the contribution of each factor to alteration of streamflow was assessed for high and low flow seasons.

Acknowledgements

This research was supported by a grant (11-TI-C06) from Advanced Water Management Research Program funded by Ministry of Land, Infrastructure and Transport of Korean government

Determination of the Erosive Potential to Cienfuegos Bay in Cuba, Using the SWAT Hydrological Model.

Sánchez Llull M., Muñoz Caravaca A., Sánchez Pérez J.M., Sabine Sauvage S., Viera Cañive M., Castellanos Torres L., Yamila Vigo Cuza Y., Estupiñán L., Barcia S.

Abstract

The Cienfuegos Bay in Cuba receives the contribution of four rivers where agricultural and industrial development is one of the most significant of the Cuban central region. The erosive processes in these watersheds imply the dragging to this ecosystem of sediments and contaminating loads that are accumulated in the bay. Although we achieved measurements of the water quality in the effluents that enter the ecosystem, these have been addressed fundamentally to estimate the impact of punctual sources of contamination and predict the load whose origin is diffuse and the loads that come from the erosive processes by tributaries. In this work we implement SWAT hydrological model (Soil and Water Assessment Tool) to evaluate the sediments discharge that contribute to Cienfuegos Bay at the hydrographic watershed. The results constitute a tool for the administrators of forestal, hydric and soil resources because it allows them predicting the impacts of land use variations on water quality and help them to reduce water pollution and erosive processes.

Modeling pollutants inputs in a reservoir using SWAT model in the Mayabeque catchment (Cuba)

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Abstract

Swat model is applied to the Mayabeque watershed (984 km2) to simulate pollutants input to the Mampostón reservoir located at the output of the catchment. This catchment is composed by two parts, one karstic part with a low concentration in sediment to the reservoir and a sedimentary part, very anthropic, with different industries using metal. Concentration in metals in the reservoir sediment (Ni, Cu Zn, Pb ,…) as a result of the industrial activities in the catchment.

River discharge and suspended sediments was calibrated at monthly scale to calculate the input part of the two parts of the catchment. Simulations permit to quantify the reservoir input of suspended sediments and allow evaluating the effect of reservoir in suspended sediments dynamics by comparing input simulations and output data at monthly time scale.

This work will be used as a start point for a forward application of the model in which it will be taken into account both land use and climate changes to evaluate the future inputs in water, sediment and metals in the reservoir at the catchment scale.

Implementation of VFS in the reservoir watershed of NE Slovenia

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Abstract

Ledava lake (218ha, 5,64mio m³) in NE Slovenia is a reservoir with excessive loading of nutrients and sediments. Site analysis showed that agriculture still always contributes most of nutrients and sediments into the Ledava lake.

In cases of diffuse pollution from agricultural areas of watershed, Vegetative Filter Strips (VFS) have been successfully used to mitigate sediment transport and retention of nutrients as pollutants. VFS effectiveness for a given load depends on the structure i.e. quality of vegetative cover within the filter and size of VFS, as from the site where we place VFS.

In the process of site selection watershed drainage networks, slope, soil texture, land use maps, point and diffuse sources of nutrient delivery were generated, using GIS and statistics.

In order to achieve optimal effectiveness of VFS to reduce sediment and nutrient loads in the reservoir, different scenarios of VFS implementation in watershed will be modeled using Soil and Water Assessment Tool (SWAT).

Keywords

Lake watershed, vegetative filter strip, site selection, Soil and Water Assessment Tool

Future variation of pathogenic bacteria concentrations depending on climate change in the Yeongsan River basin, Korea

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Abstract

The fate and transport of pathogenic bacteria from lands into waterbodies is a significant issue in a watershed, especially causing outbreaks of infection among the human population. Similar to water pollution by eutrophication due to excess nutrients, water pollution by pathogenic bacteria can be incurred by point and nonpoint sources. In particular, nonpoint sources of bacterial pollutant are difficult to identify due to various sources (e.g., animal production units, land application of different manure types, and wildlife) and complexity of environmental change (e.g., climate change and land use change). The objective of this study is to assess the change of pathogenic bacteria concentrations released from the land areas in terms of climate change. In this study, Soil and Water Assessment Tool (SWAT) model with the modified bacteria subroutine was applied to predict pathogenic bacteria concentrations in the Yeongsan River basin using the geographic information (i.e., digital elevation map, land use, and soil type), monitored data (i.e., meteorological data, streamflow, and water quality), and simulated climate data based on the general circulation model (GCM). The SWAT model provided an accurate prediction for the current pathogenic bacterial concentrations in the stream and this accuracy subsequently facilitated reliable prediction for future pathogenic bacterial concentrations with respect to climate change. This study will be useful for simulating future pathogenic bacterial concentrations and for developing effective management schemes in the watershed.

Modeling the effect of hills lakes on water discharge of the Upper Garonne river basin

Joël Payoux, Yi Hong, Maud Balestrat, Raghavan Srinivasan, Jeff G. Arnold, Olivier Therond, José-Miguel Sanchez-Perez , Sabine Sauvage

Abstract

Water scarcity is a serious problem in the Adour-Garonne Basin (AGB, South-West France) with an annual deficit between demands and resources of 250 million m^3. In this basin, irrigated agriculture is the main consumer of water (about 80%) during the low-water period.

Irrigated farmers withdraw water from rivers, shallow aquifer and many hill lacks. Several French institutions involved in water management assume that these numerous hill reservoirs (lacks) have a strong influence on the intensity and duration of the low-water periods.

The project MAELIA (Multi- Agent for Environmental Norms Impact Assessment) aims to develop a multi-agent system to represent the interactions between human activities and hydrology, especially between farming and low flow of rivers in the AGB. In this multi-agent system, representation of hydrology is based on SWAT formalisms.

The objective of this study is to present how we are adapting and applying the SWAT (Soil and Water Assessment Tool) formalisms to quantify the role of the hills lakes on hydrologic cycles on the upper part of the Garonne river. Purpose of this modeling approach is to represent and assess to what extent hills reservoirs limit increasing of river water flow by intercepting water during the rainy period. It will allow representing impact of irrigation practices on water level in hill reservoirs.

Operational objective of this study is to develop a new representation of hydrological processes of hills reservoirs at watershed level and integrate it into SWAT model and MAELIA modeling platform to simulate their effect on low waters.

Keywords

SWAT, MAELIA, low-water period, hill lake, hydrological model

Evaluation suspended sediment loads in a watershed using eco-hydrological model SWAT.

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Abstract

The main objective of this paper is to evaluate suspended sediment loads in the Oka watershed of 32 km2, north Spain, through the modelling process using physically based, distributed model Soil Water Assessment Tool 2009. The model was selected for this study due to its ability to simulate the impact of management decisions on water, sediment and chemical yields in large river basins in relation to soil, land use and management practices.

The model simulations are completed using 3 year historical record (2009 – 2012) of flow for parameter calibration. The paper also discusses the results of model calibration, parameterization and presents optimum model parameters. The river discharge estimated from the model was compared with observed flow using statistical parameters so as to evaluate performances of the recent hydrologic simulations in the watershed. The predicted daily average total flow matched the observed values with a Nash–Sutcliff coefficient of 0.71 and coefficient of correlation of 0.71 for calibration water discharge and 0.51 for sediment transport. Analysis of sediment variations in Oka river has been discussed through observed data and simulation results.

Significance of Uncertainty in Evapotranspiration Estimates on Water Balance Modeling in SWAT

Ali M. Sadeghi, Peter C. Beeson, Craig S.T. Daughtry, Jeffrey G. Arnold, Martha C. Anderson, Christopher Hain, Joseph G. Alfieri and William P. Kustas

Abstract

In water quality models, such as the Soil and Water Assessment Tool (or SWAT), accurate forcing of potential evapotranspiration (PET) is crucial for producing reasonable predictions of water budget components, sediment and other pollutant loads from larger river basins. Methods and data, needed to compute PET, vary in space and time such as air temperature, vapor pressure, wind speed, and solar radiation. In SWAT, PET is required as an input and is either computed internally by the weather generator using available weather data by a choice of three different methods: i) Priestly-Taylor; ii) Penman-Monteith; and iii) Hargreaves methods, or calculated by an external source and provided to SWAT as an input. The actual ET (AET) is then calculated in SWAT based on available water, crop and soil moisture conditions. Most often, the modelers rely on the models to simply match AET annual means, provided by the literature values, when calibrating the models due to sparse data (both temporal and spatial). For this study, we used three methods to calibrate AET parameters: i) basin-wide/annual (using literature values); ii) subbasin/monthly (using Atmosphere-Land Exchange Inverse (ALEXI) model output); and iii) HRU/daily (using the NDVI/crop coefficient method from two in situ towers in corn and soybean fields). After calibration, most PET inputs produced accurate AET estimates on a basin-wide, annual basis; however, on finer spatial and temporal scales, PET computed from local or regional data performed the best. The weather generator inputs were only able to capture the annual averages, not the variation throughout the growing season affecting biomass and yield estimates. This research provides insight into the importance of correct estimations of both potential and actual ET for water balance components and for the application of physically-based watershed models.

Keywords

SWAT, Potential evapotranspiration (PET), Actual evapotranspiration (AET), Watershed Modeling

Simulating river discharge in a mountain river using climatic conditions from today to the last 12000 years using SWAT model

Sanchez-Perez, J.M., Pinglot, F., Dupleich, Y., Le Roux, G

Abstract

SWAT model was used in the Vicdessos watershed (8.2 km^2) in the Pyrenees Range in the upper part of the Garonne basin to simulate river discharge at the daily step for 50 years (1962 to 2009).

Results show an acceptable simulation with a Nash-Sutcliffe coefficient of 0.82. The use of elevation bands was essential, as well as the calibration of the snow-related parameters. SWAT-CUP, a sensitivity analysis tool was used to define the best parameters needed. Then we analyse climate and land use influence on stream flow using paleo-environmental conditions (T°, rainfall and land cover) as defined by local environmental archives (peat, lake) and regional reconstructions of past temperature and rainfall from today to the last 12 000 years.

The tested climatic conditions varied from -10% to +150% in precipitations and -1.4 to +2.6 °C for temperatures compared to present conditions. It reveals a high sensitivity of both climate and land use on water discharge.

Modelling of surface water contamination risks by using RNN and SWAT model : the case of the SAVE river (South-West of France).

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Abstract

The degradation of streams quality impacts heavily continental ecosystems. From an ecological point of view as well as economic, the conservation of our streams is a major stake of our time. The agricultural activities are the main cause of contaminants agents' contributions within the Southwest European watersheds. The European *Aguaflash Interreg IVB SUDOE* project aims at supplying tools allowing estimation of pollutants concentrations in particular pesticides which will be transported from agricultural lands to the most close streams. According to this project, our study containing three steps tried (i) to identify factors of control of the pollutants transfers as sediments and nitrates, (ii) to model transfers from these factors of control in an agricultural European Southwest watershed, and (iii) to build a map of this watershed including the distinction between high-risks and low-risks zones. The modelling was made by SWAT model in the case of the Save river (Southwest of france) for sediments and nitrates. Input variables were chosen as controlling factors for nitrates and sediments transfers. Based on these inputs and on output variables simulated by SWAT model, we used Artificial Neural Networks (ANN). The first ANN was built to model flows, the second to estimate sediment yield and the third to evaluate the transfers of nitrates. The ANN results brought us coherent results in a satisfactory way to simulate sediments and nitrates dynamics on the whole hydrographic system of the watershed. Data come from field samplings and SWAT model simulations, allowing us to generate data on the whole watershed area.

Keywords

SWAT model, Artificial Neural Networks, Dissolved phase, Particulate fraction, Save river

Predicting Sediment Production and Transfer Rates in a Semi-Arid Catchment in Jordan

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Abstract

This paper examines erosion and sediment transport within the Wala Dam catchment, one of the most important water resources in Jordan, with groundwater providing potable water supplies to the capital Amman and surface water used for agriculture. This study employs SWAT to investigate sedimentation rates within the catchment and the subsequent impact on the functionality of the Wala Dam as an artificial groundwater recharge structure. A geospatial database containing geography, topography, landuse, soil classification and weather of the area has been built. The model comprises of three main components: topographic watershed delineation into sub-basins; definition of hydrologic response units; and definition of weather characteristics. Limited data availability presents a challenge to the development of the model; hence, different sets of input data from various sources have been tested to assess the best set of conditions. Model calibration and validation will be accomplished, using stream flow measurements and sediment load values extracted from a sediment survey previously accomplished at Wala gauge. One of the principal challenges in the model calibration has been the definition of landuse and soil types. This paper will examine the value of using bespoke landscape mapping compared to the best generally-available datasets. To date, the model has shown promising performance in simulating the hydrology and sedimentation rates across the area, but the preliminary findings indicate that without changes in management, unsustainable sediment delivery into the reservoir will continue. Future research will investigate rates of change and management mechanisms for reducing erosion and minimizing sedimentation rates at Wala dam.

Keywords

Erosion; hydrology; sediment transport; SWAT; Wala Dam, Jordan.

An APEX bibliography since 2004

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Abstract

The Agricultural Policy EXtender (APEX) model is a farm to watershed scale model developed to address environmental problems associated with a range of agricultural production systems. APEX was designed to model small to large watersheds (10s to 1000s of km^2) with a high level of water quality and hydrologic detail. APEX is explicitly spatial with routing for above and below ground water flow through the landscape. It also explicitly models plant growth and crop management as part of the simulations and is often used to generate data for analysis in SWAT which aggregates APEX output in very large watersheds (>10,000s of km^2). Since its introduction in 1995, APEX has been used for on-farm analyses to assist growers make conservation decisions and at larger scales to inform conservation policy decisions. It is an important component of USDA-NRCS Conservation Effects Analysis Program (CEAP). A 2005 review collected research papers citing APEX. This paper reviews research since then, with special reference to projects involving both APEX and SWAT.

SWAT model application in Simulating the Hydrology of Great Ruaha River Sub-basin in Tanzania

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Abstract

Distributed hydrological watershed models are increasingly being used to support decisions about alternative management strategies in the areas of land use change, climate change, water allocation, and pollution control. The main objective of this study was to assess the performance and applicability of the soil water assessment tool (SWAT) model for prediction of stream flow in poorly gauged Great Ruaha River Sub-basin. Precipitation and temperature data are the key inputs in SWAT model. However, in developing countries, records collected in long periods of time contain gaps. The common practice has been to use SWAT's built in stochastic weather generator, WXGEN for filling missing data. For this reason satellite data were used in stream flow simulation. This was found to provide better estimates of SWAT stream flow by 13% and 37% using the Coefficient of Determination (R^2) and the Nash-Sutcliffe efficiency (NS) respectively. During model set-up, a reduction of the number of model parameters was obtained using an LH-OAT sensitivity analysis. The selected parameters were optimized by a manual and an auto-calibration. In general, a reasonably fair match was observed in the shape of simulated and observed hydrographs for the 1960's – 1970's calibration and 2000's-2009's validation periods. The model evaluation statistics were verified by R^2 and NS values greater than greater than 0.5 and 0.4 during calibration and validation respectively, which is a satisfactory accuracy among the applications of SWAT model.

Modeling riverine fluxes of dissolved and particulate organic carbon on a large fluvial basin: the Garonne River (South-West of France)

Andoni Uhart, Sabine Sauvage, Jean-Luc Probst, Raghavan Srinivasan , Jeff G. Arnold , José-Miguel Sanchez-Perez

Abstract

Dissolved and particulate organic carbon fluxes in rivers are involved in biogeochemical cycles and pollutant transports. The organic carbon transported in rivers have different origins (mechanical and chemical erosion from lands, in-stream production or coming from leaves and domestic effluents). These fluxes transferred in the catchment and in the river continuum can be associated to other molecules such as metals or pesticides. The organic carbon is transported through the water column in dissolved (DOC) and particulate (POC) forms. The dynamics of DOC and POC are very complex because of the different origins of the carbon, its biodegradability and its transport processes associated which are greatly variable in time and space at the scale of a watershed. In order to assess the dynamic of these two organic carbon forms and to quantify their fluxes, we need to model the processes in the simplest way possible.

The main purpose of this study is to model the fluxes of organic carbon in their various forms in the Garonne river basin (South-West of France, 52000 km²). We will focus on the hydrological behavior of the catchment by studying the transfer of water, suspended matter and organic carbon in its two forms and compared with data obtained at the outlet of different sub-basins. A first data analysis show that DOC and POC have relationships with some parameters easy to measure or to model like riverine suspended sediment and soil carbon content.. So the idea is to test different relationships by modeling at different space scale in the case of the Garonne watershed.

At the catchment scale, the hydrological process model and the transfer of minerals need to know the characteristics of the soils and the land covers. To overcome all these kind of problems, it will be necessary to use a model considering all of those parameters spatially. It is the reason why we decided to work with the SWAT model applied to the Garonne river basin and to integrate the organic carbon river flux modeling based on some parameter controls easy to measure or to model. Simulate over a long period how the system will answer to all the different changes (climatic, ecological, land covers…) that could happen and predict the response in term of organic carbon river fluxes to these change scenarios.

Keywords

SWAT**,** Organic carbon, Suspended matter, Modeling, Climate change

Analysis of Water Resource on Major Baseflow Watershed of southern area in Jeju Island, Korea

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Abstract

Jeju Island is a volcanic island located at the southernmost of Korea, and is the heaviest raining area in Korea, but due to its hydrological/geological characteristics different from those of inland areas, most streams are of the dry form, and it relies on groundwater for water resources. As for some streams, however, spring water is discharged at a point near the downstream of the final discharge to maintain the flow of the stream; this has been developed as the source for water supply since the past, but the studies on precise observations and analysis are yet inadequate. This study utilizes the ADCP (Acoustic Doppler Current Profiler) hydrometer to regularly observe the flow amount of base run-off stream, and the water resources of major baseflow watershed of southern area of Jeju Island were analyzed using the SWAT (Soil & Water Assessment Tool) model. The precise water resource analysis study using modeling technique and site observation with high precision for Jeju Island water resources is expected to become the foundation for efficient usage and security of water resources against future climate changes.

Assessment of the environmental fate of the herbicides Flufenacet and Metazachlor with the SWAT model

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Abstract

This study aims to assess the environmental fate of the herbicides Flufenacet and Metazachlor in the Northern German Lowlands with the ecohydrological Soil and Water Assessment Tool (SWAT model) and to test the sensitivity of pesticide related input parameters on the modeled transport dynamics. The river discharge of the Kielstau watershed was calibrated (NSE: 0.83, r^2= 0.84) and validated (NSE: 0.76, r^2= 0.77) for a daily time step. The environmental fate of the two commonly used herbicides Metazachlor (NSE: 0.68, r^2= 0.62) and Flufenacet (NSE: 0.13, r^2= 0.51) was simulated adequately. In comparison to Metazachlor the simulated Flufenacet concentration and loads show a lower model efficiency due to the weaker simulation of the stream flow. The in-stream herbicide loads were less than 0.01 % of the applied amount in the observed time period and thus not in conflict with European Environmental Legislation. The sensitivity analysis showed that besides the accurate simulation of stream flow the parameterization of the temporal and spatial distribution of the herbicide application throughout the watershed is the key factor for appropriate modeling results, whereas the physico-chemical properties of the pesticides play a minor role in the modeling process.

Using SWAT models to inform catchment management approaches to pesticide control – A UK Water Industry Case Study.

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Abstract

The UK Water Industry is concerned about metaldehyde (used in some molluscicides) which is being found in surface water and groundwater. A regulatory limit of 0.1µg/l of any pesticide is in place for drinking water. Concentrations above this limit have been recorded in raw water and metaldehyde is difficult and expensive to remove through water treatment. Anglian Water, the largest UK water company by area, is exploring the potential benefits of working with the agricultural sector to change how, where and when metaldehyde is used – work which falls under their catchment management programme.

The potential effectiveness of catchment management in reducing diffuse metaldehyde pollution is being investigated using SWAT. In total, 23 surface water catchments are being modelled. The models are being calibrated using measured stream flows and metaldehyde concentrations. Catchment management scenarios are then modelled by changing the land use and management operations in SWAT.

New approaches and tools have been developed to apportion arable crop types based on historic percentages of arable land and assuming typical crop rotations. Stochastic techniques have been used to select subbasins/HRUs to implement catchment management scenarios by changing land use and reducing metaldehyde applications, and/or using alternative pesticides. The results of these scenarios are informing Anglian Water's business planning for catchment management.

This paper describes how SWAT is being used to test catchment management scenarios; sets out the methods that have been developed to implement the scenarios; and, shows how the results are being compared and interpreted.

Keywords

SWAT, catchment management, pesticide, metaldehyde, diffuse pollution, water quality, land use, management operations.

Implementation of a new module to simulate trace metals transport in large rivers by coupling SWAT and MOHID models: The case of the Garonne River (France)

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Abstract

River contamination by trace metal (TM) is an increasing environmental problem. The metal transfer remains complex to model and is therefore poorly documented or excessively simplified at a large river scale.

We propose a new model for trace metals transport in large rivers. The physical transport of TM (through the advection / diffusion equations) is simulated coupling the SWAT model and the MOHID River Network (MRN). This coupling allows to generate the run-off and suspended solids of the sub-watersheds with SWAT and to compute the water routing process with the MRN. The MRN allows to provide a fine morphology of the river, thus improving the hydrodynamics. The trace metals are then transported by the advection / diffusion equations. The proposed module includes transient storage and sorption / desorption equations. This new sorption module generated a better description of sources and sinks.

The coupled SWAT and MRN with TM transport model was tested to the Garonne River (SW of France) in its middle course. Two trace metals were chosen for their contrasting sorption behavior on suspended matter. Arsenic (As) was mostly on a dissolved form whereas lead (Pb) displayed a significant particulate fraction. The first modelling outputs were compared with measured trace metals data obtained under various hydrological conditions. We discuss the simulated data and the limits of this first modelling approach to describe trace metals transport in large rivers.

Keywords

Modelling, transient storage, arsenic, lead, hydro-morphology, hydrodynamic

New insight into pesticide partition coefficient Kd for modelling pesticide fluvial transport with the SWAT model

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Abstract

Pesticides used for crop protection are known to be leached with rainfall events to groundwater and surface water. The bioavailable dissolved fraction threatens the fluvial ecosystems. Pesticide partitioning in the environment is therefore one of the key pesticide fate processes that should be properly formalised for risk assessment. In modelling approaches, the partition coefficient K_d is usually estimated from different empirical models based on laboratory batch studies, such as Karickhoff and Chapra's equations whose use is recommended by the SWAT manual. A preliminary study showed that the partition parameter in SWAT was more sensitive in the river network than in the soil. Therefore we sought a new relationship for the partition coefficient $K_d$in rivers, relating K_d to the octanol/water distribution coefficient K_{ow} and to the Total Suspended Matter (TSM) concentration. This relationship was obtained from in-stream measurements of TSM, of Particulate Organic Carbon (POC) and of 7 pesticide molecules (alachlor, atrazine, DEA, isoproturon, tebuconazole and trifluralin) sampled form 2007 to 2010 at the outlet of the 1110 km² River Save catchment. We first sought a relationship between TSM and the percentage of POC in TSM. We then related the organic carbon normalised partition coefficient K_{oc} to K_{ow}. We showed a bias of 0.5 between in-stream observed K_{oc} average values and K_{oc} values calculated with Karickhoff's equation. By combining both relationships, theK_d was expressed as a function depending on the widely literature-related variable K_{ow} and on the commonly observed and simulated TSM concentration. Our equation will be implemented in the SWAT model,K_d thus becoming a variable in time and space depending on simulated TSM concentration. The K_d calculation method described here can be applied to a wide range of catchments and organic contaminants.

Keywords

Sorption, Dissolved phase, Particulate fraction, Flood, SWAT model, Save rive

Assessment of the combined effects of climate and land use change in Lusatia, Central Europe

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Abstract

Lusatia, characterised by a continental climate, is located in Central Europe. Already under current conditions, the climatic water balance is negative and limits crop growth unless irrigation water is available. Due to global climate change, increased temperatures and a shift of precipitation from summer to winter are expected. In order to account for renewable energy production an increasing cultivation of energy crops such as oilseed rape, silage maize, sunflower, sorghum and sugar beet is assumed. The aim of the study is the assessment of the effects of both climate and land use change on the water balance. For this purpose, the ecohydrological Soil and Water Integrated Model (SWIM), driven by climate change scenarios of the statistical regional climate model Statistical Analogue Resampling Scheme (STAR, scenarios 0K, 2K and 3K), was used. Land use changes were accounted for by variation of the dominating crop.

Simulation results show declining actual evapotranspiration and discharges in the vegetation period for most of the catchments due to changing climate conditions in STAR 2K and 3K scenarios, leading to lower yields for the typically grown winter wheat in the region. The effects of climate change are attenuated in simulations with oilseed rape, but slightly amplified in simulations with silage maize, sorghum and sorghum hay. For silage maize, sunflower, sorghum hay and sorghum there is a clear positive trend in yield with increasing temperature in the scenario. The effects on the yield of oilseed rape are spatially more heterogeneous.

Keywords

Biofuels, SWIM, Climate Change, Land Use Change, Mining

Lessons learnt from multiple applications of SWIM for climate impact assessment and its involvement in the model intercomparison project

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Abstract

The Soil and Water Integrated Model (SWIM)is a continuous-time semi-distributed ecohydrological model for the river basin scale. It was developed based on SWAT and MATSALU models for climate and land use change impact assessment. During the last decade SWIM was extensively tested in mesoscale and large river basins, and several modules were further developed (e.g. wetlands and snow dynamics) or introduced (glaciers, reservoirs). Some exemplary studies on impact assessment will be shortly presented, and several questions important for impact modellers will be discussed:

- Where are the limits in model application and how the further model development can help to overcome some of them?
- How to apply the model in data-poor situations or in ungauged basins?
- How to use the model in basins subject to strong anthropogenic pressure?

The SWIM model is now involved in the intercomparison of impact models, which is ongoing for global and regional-scale models and for several sectors, following the intercomparison of climate models. Bridging the scales between global and regional impact research is needed, and it can be done as a top-down or a bottom-up approach. Therefore, projections of climate impacts must be provided at the regional scale more systematically, and intercomparison of regional impact models is important to assure the robustness of results. The concept and plan for the intercomparison of regional-scale hydrological models (including SWIM and SWAT) in the framework of the ISI-MIP project will be discussed in the presentation.

Experimental drought early warning system in the Niger river basin

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3. Altenburg & Wymenga

Abstract

The Niger river basin experiences a high seasonal and interrannual climate variability with severe dry episods affecting the regional food security and socio-economic development as well as the conservation of wetlands and semi-arid ecosystems. It results in an increasing competition and conflicts for water and natural resources between vulnerable local stakeholders (rainfed and semi-controlled irrigation farming, nomadic pastoralism, traditional fisheries) and steers national investments with the construction of dams and diversion channels for the development of hydropower energy and fully governed irrigated agriculture.

In this context, the use of tailored forecast system information can improve drought preparedness contingency planning and strategic decision-making at river basin and community scales.

This study aims at presenting mid to long term hydrological forecast systems in the Upper Niger Basin and the Inner Niger Delta. Based on water level time series, the skill of the statistical model OPIDIN (Outil de prédiction des Inondations du Delta Intérieur du Niger) is assessed for mid term responses. The Soil and Water Integrated Model (SWIM) projects long term drought pattern using ISI-MIP Earth System Models. Calibrated with Watch Forcing Data, SWIM incorporates different scenarii of main operationnal water managements of the river basin (reservoirs and water uptake from irrigation schemes) as well as an inundation module accounting for flood propagation processes in the Inner Niger Delta.

Climate change: Impact on nitrogen export from different land-use types in a reservoir catchment

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Abstract

Climate change scenarios for Central Europe predict both an increase of temperature and a shift in the annual distribution of precipitation. In the German state of Saxony, climate change is predicted to increase precipitation during the winter, and decrease in the summer. These changes will affect the nutrient cycling in soils.

The REGKLAM-Project will establish an *Integrated Regional Climate Change Adaption Programme* for the region of Dresden. One focal point of this project is water quantity and quality. Drinking water supply for this region is provided by a water reservoir network located to the south of Dresden in the Eastern Ore Mountains. Therefore, it is important to analyze the pollution sources (and regional climate change effects) that affect the water quality and quantity of that network. We established a comprehensive hydro-chemical monitoring program to quantify the contribution of different land-use types (farmland, grassland, and forest) on the nutrient export to surface waters. This monitoring program included both continuous and event-based discharge and water quality sampling at the plot scale (specific land-use types), and at the catchment scale at the reservoir inlet. The collected results were used to adjust then SWAT model parameters used to represent nitrogen cycling.

To estimate the regional climate change effects on nitrogen exports we used climate data predicted by the regional models WETTREG 2010 and CLM. Simulations covered the time period 2009 until 2100. In our presentation we will show the results obtained by this combination of the comprehensive hydro-chemical monitoring program with the SWAT model.

Integration of the SWAT landscape model into a grid-based setup

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Abstract

Integrated river basin models should require a spatially distributed representation of basin hydrology and transport processes. However, the conventional sub-watershed discretization in SWAT is unable to account for spatial variability within a sub-basin and to simulate runoff and infiltration processes that typically occur in a landscape.

To overcome these difficulties, SWAT is currently being modified to enhance its spatial representation of hydrology and transport processes within a watershed. For this purpose a landscape routing model was developed, which enables the distribution of runoff, sediment and nutrients between sub-watersheds, grid cells, or routing units in the land-phase of the hydrologic cycle. The landscape routing was integrated into a SWAT prototype and was tested using different landscape delineation methods. The combination of the landscape routing and SWATgrid, an interface preparing the input data for setting up SWAT based on grid cells, results in a spatially fully distributed model that includes surface, lateral, and groundwater fluxes in each grid cell of the watershed.

We present the evolution of the SWAT landscape model to a grid-based setup and first results of water balance simulations. Further, the spatial distribution of surface runoff, subsurface flow and evapotranspiration as well as the hydrograph at the watershed outlet are examined. We discuss present developments as well as occurring problems before we finally point out future steps.

Modelling epilithic biofilm biomass in large rivers to be integrated in SWAT model: comparison between the Garonne River (southwest of France) and the Xiangxi River (China)

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Abstract

The epilithic biofilm is a functional indicator of river health and a source of organic matter that can complex with contaminants (metals, pesticides …).

Different models to simulate the dynamic of the epilithic biofilm previously developed in the case of the Garonne river (6th order in its middle course), south west of France (Boulêtreau et al., 2006, 2008; Graba et al., 2011, 2013) were tested in the Xiangxi river in China (6thorder, one tributary of the Yangtze River). Both rivers are gravel bed rivers with important slope and relatively high velocity. In order to identify the most adequate model with few parameters, we tested the model with 3 parameters and only with one input data, daily discharge. The simplified model is based on growth and detachment terms: the first parameter represents the maximum specific growth rate at the reference temperature 20°C, the second one is theinverse half-saturation constant for biomass that limits the growth, and the last one is an empirical detachment coefficient. Q (m3/s) is the daily discharge as an input for the model. This model was tested in 4 study sites of the Xiangxi river (2 sampling stations in the main course of the river and 2 stations in tributaries). The model was compared to data of chlorophyll a from September 2004 to June 2007.We used SWAT model (Bieger et al., 2013) to simulate daily discharge at the different sampling sites in order to run the epilithic biofilm model at the scale of the watershed. The simulations showed a good agreement with the data but the parameters used for the calibration changed from one site to another, showing that the structure and composition of the epilithic biofilm is highly different. In a second step we propose to include the epilithic model in SWAT to model biofilm dynamics at reach scale. In order to achieve this goal we need to describe hydro-morphological parameters in rivers and integrate additional control parameters like light intensity.

SWAT model improvements: evidence based and conceptual validation

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Abstract

Open source code is one of the strengths of the SWAT model enabling users to improve the model with new concepts, ideas, or specific research needs. However, when a process representation in the model is updated, the model output must be validated. We discuss two validation methods used in separate model improvements made to evaluate impacts of bioenergy crop production on environmental sustainability: (1) evidence based model validation with field measured data; and (2) conceptual model validation with process understanding and simulated scenario comparisons. In the first study, crop growth algorithms were modified to better represent perennial crop production, such as Miscanthus and switchgrass to evaluate potential impacts of bioenergy crop production on environmental sustainability. The method followed a systematic approach of identification of sensitive parameters, estimation of parameter values with field measured data and modification of model codes to better represent the growth characteristics as observed in the field. The model improvements were validated with field measured crop growth data. The second study aimed to improve the vegetative filter strip (VFS) representation in SWAT model to improve hydrologic process representation and quantify biomass productivity of VFS area. The improved model representation enables routing of water, sediment and nutrients from source area through the VFS area. The modifications also allow infiltrated water and nutrients to be available for crop uptake in VFS area. The model code modifications were tested through hypothetical VFS case study scenarios as conceptual validation of the processes represented in the model.

Integration of a pseudo 3D finite element ground water model with SWAT

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Abstract

In SWAT, the non-steady-state response of groundwater flow to recharge is modelled by combining the stready state Hooghoudt's equation originally developed for designing the spacing of sub-surface drains with the equation for water table fluctuations developed by Smedema and Rycroft (1983). The limitation of this approach is that the ground water interaction among the HRU and subbasin are ignored. However, in large basins with varying topography, ground water interaction among the HRUs/Subbasin will be vital to assess the baseflow contribution to the streams. Further, transmission losses from the streams upstream (loosing stream) could contribute to ground water and return back as base flow and enter the streams further downstream (gaining stream). In the past, for realistically modelling this shallow ground water flow, surface water ground water interaction, SWAT has been externally/loosely coupled with MODFLOW and other ground water models. In the present study, an attempt has been made to tightly couple SWAT with a pseudo 3D finite element ground water model to model the shallow aquifer. The pseudo 3D finite element model implemented uses the Galerkin method with linear triangular elements. The finite element model solves the simplified form of ground-water flow in a saturated media stemming from Dupuit's assumption, where the ground-water flow is assumed to be horizontal and vertical gradient is neglected. This coupled model has been applied to a watershed in India to assess the baseflow.

Sediment load responses to simulated conservation management practices - towards water and soil protection in a Central Brazilian catchment

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Abstract

The intense use of water for both public supply and agricultural production causes societal conflicts and environmental problems in the Brazilian Federal District. A serious consequence of this is nonpoint source pollution which leads to increasing water treatment costs. Hence, we will present a case study investigating how agricultural Best Management Practices might contribute to sustainable water resources management and soil protection in the region. The SWAT model was used to study the impact of those practices on water and sediment yield in the intensively cropped catchment of the Pipiripau River. The model was calibrated and validated against measured streamflow and turbidity-derived sediment loads. By means of scenario simulations, it was found that control constructions such as parallel terraces and small sediment basins (‘Barraginhas’) can lead to sediment load reductions of up to 40 %. The implementation of these measures did not adversely affect the water yield. In contrast, multi-diverse crop rotations including irrigated dry season crops were found to be disadvantageous in terms of water availability by significantly reducing streamflow during low flow periods. The study considers rainfall uncertainty by using a precipitation data ensemble, but nevertheless highlights the importance of well-established monitoring systems due to related shortcomings in model calibration. Despite the existing uncertainties, the model results are useful for water resource managers to develop water and soil protection strategies for the Pipiripau River Basin and for watersheds with similar characteristics.

Development of Generic Landscape-level Stormwater Retention/Treatment BMP in SWAT

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Abstract

The paper describes modifications to the Soil and Water Assessment Tool (SWAT) default pothole algorithm to simulate the implementation of stormwater best management practices (BMPs) at the landscape level. The modifications are intended to support analysis of the effects of stormwater BMPs on a watershed by aggregating site-level BMPs determined by a detailed engineering analysis, to the level of SWAT HRUs. The new code allows specification of the total BMP volume, along with the discharge rate and maximum effluent concentration limits. The infiltration rate is determined by the HRU soil profile.

The paper describes the implementation of the code in SWAT using an example application in a watershed in North Carolina to estimate the effects of different BMP specifications (retention only, retention and treatment, varying volumes and effluent limits, etc.) on the resulting flows and water quality.

As shown in the paper, the generic SWAT stormwater BMPs provide results that are consistent with expectations. The implementation of stormwater BMP reduces the magnitude of the peak runoff from the managed land area – with larger BMPs showing larger reductions. The available volumetric capacity of the BMP determines the amount of water that bypasses the BMP without treatment. The retained/infiltrated stormwater is released back to the reach over time via lateral and groundwater flows, minus any aquifer recharge, or via treated surface discharge from the BMP, as shown by slightly higher reach flows on days following the rainfall event, compared to the “no control” scenarios. The BMPs also have the expected effects on stormwater pollutant loads and in-stream water quality, with reductions in nutrient and sediment concentrations associated with retaining the runoff and/or treating the retained water to specified effluent limits.

Overall, the results demonstrate the feasibility of using an aggregate BMP approach to efficiently model the effects of stormwater controls in large watersheds.

Keywords

BMPs, stormwater, infiltration, treatment

Assessment of agricultural best management practices using mathematical models: a review

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Abstract

Best Management Practices (BMPs) are one of the most effective methods to control nonpoint source (NPS) pollution. Mathematical models are important tools to facilitate in evaluating both non-structural and structural BMPs for watershed management. This review will focus on the assessment of agricultural BMPs at the field scale and watershed scale. A number of researches of state-of-art modeling strategies are reviewed and four watershed models (SWAT, AGNPS, AnnAGNPS, and HSPF), as well as two BMP models (VFSMOD and REMM) are analyzed and their strengths and constraints are compared in detail. Recommendation for simplified tools and integration approaches are also provided. This paper indicates mathematical models are generally the conceptualization of the way in which the BMPs system functions and the model parameters and structures are, therefore, defined as the quantifiable processes based on the characteristics of BMPs. However, the assessment of agricultural BMPs is strictly scale-dependent. Therefore, model users should pay great attention to the scale issues involved in the assessment of BMPs using models. A systematic decision support system (DSS), which combinations watershed models and BMP models, may be a positive hint for the purpose of evaluating BMPs. This review will attract a wide range of readers concerned about the NPS pollution and watershed management.

Keywords

Best Management Practices; mathematical models; assessment; scale-dependent; decision support system

Assessing the impact of climate change scenarios on water resource in the Bhima river basin in India

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Abstract

In this study, impacts of climate change on water balance components in the Bhima river basin in are investigated. A distributed hydrological model namely Soil and Water Assessment Tool (SWAT) has been used for study. Using outputs from RCM, viz. PRECIS ("Providing REgional Climates for Impacts Studies") are applied to generate daily monthly time series of precipitation, surface flow, water yield , ET and PET. A distributed hydrological model namely Soil and Water Assessment Tool **(SWAT)** has been used for study of the Bhima river basin. Monthly calibration and validation of the SWAT model for stream flow were performed after conducting sensitivity analysis. Manual and automatic calibration methods were used for calibration. Thirty one (1970- 1990) years of meteorological and measured stream flow data were used for calibration and validation. The periods 1970-1986 and 1987- 1990 were used for calibration and validation respectively including two years of warm-up period (1970 and 1971). The R^2 value during the calibration period shows a good correlation between observed and simulated values of stream flow. The R^2 and NSE values were found to be as 0.72 and 0.80 respectively. The R^2 value during the validation period shows a good correlation between observed and simulated values of stream flow. The R^2 and NSE values were found to be as 0.69 and 0.81 respectively.

Using the calibrated model simulation at 29 sub-basins of the Bhima basin has been conducted 30 years of data belonging to control (present) and the reaming the remaining 60 years data (2011-2040) & (2041-2070) were corresponding to CHG (future) climate scenario. Quantification of climate change impact has been done through the use of SWAT hydrological model. The initial analysis has revealed that increase in precipitation has been predicted in almost half of the month of the year, while in the remaining months decrease in precipitation has been predicted. The magnitude of this increase/decrease in precipitation over the Bhima basin has been variable over various months.

Application of the SWAT Model to assess climate change impacts on water balances and crop yields in the West Seti River Basin

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Abstract

The West Seti River basin is located in the far western region of Nepal and has a catchment area of 7,438 km^2 and annual rainfall of approximately 1921 mm. According to Siddiqui et al., (2012) this basin is one of the most vulnerable in Nepal. The average elevation of the basin is 2505 m but can vary from 314 m to 7043 m in the Api and Nampa high mountain ranges. Agricultural land in this basin is categorized into three types: level terraces; slope terraces; and, valleys. The major summer cereal crops in the basin are rice, maize and millet and the major winter cereal crops are wheat and barley.

The Soil and Water Assessment Tool (SWAT) is used to simulate water balances in different cropping patterns under current and future climates. The results show that total precipitation over rice, maize, millet, wheat and barley fields are 1002 mm, 818 mm, 788 mm, 186 mm and 169 mm respectively whereas total simulated actual evapotranspiration (ET) are 534 mm, 452 mm, 322 mm, 138 mm and 177 mm respectively under current climate. Actual ET will change by +0.7% in rice, +3.4% in maize, -3.4% in millet, +41.2% in wheat and +36.2% in barley under future climate projections. Results show that yield of rice, maize and millet will decrease by 10%, 7.9% and 26.1% whereas yield of wheat and barley will increase by 7.8% and 5.8% respectively. Therefore, the impact of climate change shows that summer crop yields will decrease and winter crop yields will increase.

Keywords

Water Balance, Hydrological Modeling, Climate Change, Crop Yields, SWAT

Climate change impacts on the water resources of the Garonne River watershed

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Abstract

Most of the modeling works on the impact of climatic change in hydrology focus on overland flows or, less frequently, on aquifer recharge. This study proposes a different point of view and takes into consideration the largest part of the water cycle as possible, applying the recent concept of integrated water resources management which divides water resources into two classes: green and blue waters. Blue water groups all "visible" resources, "usable" by society, such as runoff, groundwater, and stream flow. The residual green water is by default "unusable", mainly soil water content and evapotranspiration (ET).

Hydrologic resources modeling simultaneously considering those two different reservoirs, their interrelations, and interconnections had seldom been done. What are the influences of one over the other during and after an extreme event? How those interrelations will progress under climate change?

The SWAT model was operated at the Garonne catchment (48 000 km2) scale to evaluate the evolution of blue and green waters. To be able to test the influence of climatic change, we need a model in which data's from regional climate models (RCMs) could be used. To reach this aim it was necessary to calibrate the model with weather data's in the same format as those given by RCMs: on a mesh. Météo France has such data's: from SAFRAN. Weather data's were relocated on 8km by 8km grid. Those data's were used to calibrate SWAT.

In addition to the traditional calibration, we paid particular attention to the linkage between both compartments: infiltration, "revaporation", as well as ET, which are the main green water flows.

Keywords

Climate Changes, green and blue water, Swat model, Garonne River

Intercomparison of climate impacts on four large African river basins using a regional eco-hydrological model driven by five bias-corrected/downscaled Earth System Models

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Abstract

The river basins of the Niger, the Blue Nile, the Ubangi (tributary of the Congo) and the Limpopo cover a wide spectrum of climates, topographies and ecological conditions as well as different levels/ intensities of water management that occur in Sub-Saharan Africa. Taking into account these typical characteristics we set up and adapted the model SWIM to the particular conditions and requirements of each basin in order to examine and compare climate change induced trends in discharge and water availability.

The eco-hydrological model SWIM is a semi-distributed model based on SWAT. The individual set up includes not only specific calibration but also adjustment of input-data and adaptation/ extension of the model. Main extensions comprise water management infrastructure such as reservoirs and irrigation schemes as well as wetlands and their inundation dynamics. For trend projection analysis the models are driven by downscaled climate projections of five Earth System Models.

In the results we present the individual requirements to the model set-up, which varies fundamentally between the basins. The validation shows model efficiencies ranging from adequate to good, depending mainly on quality and availability of input and calibration data. Based on this validation we compare the trends in mean discharges, seasonality and hydrological extremes. The projections agree mostly in the direction of trends; however the ranges of uncertainty for the different climate models are wide. Despite a strong warming trend in all models we remarkably found a considerable probability for an increase of discharge for means and extremes across all four basins.

Comparing the Changes in Hydrology due to Different Development Regulations using Sub-Daily SWAT

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Abstract

The City of Austin, Texas is in the process of updating its land development regulations and requested that the hydrologic impacts of the new regulations be compared to existing regulations. The authors increased the scope of the project in order to determine the overall effectiveness of land development regulations with respect to changes in hydrology. Four development scenarios were modeled using SWAT. These models represented conditions from pre-1970s through the proposed regulations and a baseline undeveloped scenario. Scenarios were compared based on impacts on flooding, erosion and aquatic life potential. Early regulations with narrow stream buffers and detention basins addressed infrequent flood events but increased the peak flows associated with return periods less than 25 years, increased excess shear and changed hydrologic metrics indicating a probable decrease aquatic life potential. Later regulations, including the proposed regulation, which include more extensive creek buffers, detention and water quality controls, controlled the infrequent flood events and decreased the peaks flows for different return periods to near undeveloped conditions, reduced excess shear and maintained hydrologic metrics aquatic life potential.

Application of the SWAT model for extreme urban flash floods of Seoul

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Abstract

In recent years, urban floods have been occurred more frequently and become more intense. Seoul, one of the biggest megalopolis cities, has experienced with severe urban flash floods in three consecutive years of 2010, 2011 and 2012. Due to the difficulties of measuring inundation depth and other hydrological features on site of urban floods, most urban drainage catchments are remained as Ungauged Catchment with high level risk of unexpected flood. This study aims to estimate amount of excess water and flood depth and to delineate flood vulnerable areas for the site of suffering from remarkable urban flash floods in Seoul. SWAT is applied for the area of Gangnam in southern part of Seoul, where has recently got lots of interest owing to the most severe urban flash flood occurred in 2011. The model was calibrated for two years (2010 ~ 2011) and validated for four years (2008 ~ 2009). The findings will be contributed for a better understanding of surface run-off for an ungauged urban catchment in terms of improving flood prediction and early warning systems. This study will be continued to couple with hydraulic models which will be developed to estimate water flow through drainage systems underground in later stage of the project which is WISE (Weather Information Service Engine, www.wise2020.org).

Keywords

Ungauged Catchment, Urban, Flood, Inundation

Using SWAT model to evaluate the impact of community-based soil and water conservation interventions for an Ethiopian watershed

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Abstract

Extensive land degradation in the Ethiopian highlands forces the rural communities to prevent further soil erosion to ensure sustainable land management in the endangered regions. Soil conservation measures are continuously being established in some areas by research and/or development projects but the effects at field and watershed level are unclear.

The objective of this study is to assess the impact of selected soil and water conservation interventions on runoff and sediment yield in the Gumara-Maksegnit watershed in the northern Amhara region, Ethiopia. SWAT model was set up to simulate the 54 km² large watershed based on SRTM-DEM data, soil data derived from 234 observations, a land-use map based on supervised satellite-image classification and weather data from four different rain gauges. Runoff and sediment concentration was monitored at three gauging stations in the watershed to provide a reliable model calibration. Comprehensive field monitoring was undertaken to assess the impact of upland and channel processes in the watershed and thus to validate the model performance. Based on 1159 mm rainfall in 2011, the calibrated SWAT model suggests 271 mm surface runoff and 22.6 t ha^{-1} annual soil loss. The achieved NSE of modelled and observed daily runoff of 0.777 indicates that the SWAT model can be used for the assessment of the on-site watershed characteristics and based on this various soil conservation scenarios can be simulated to identify efficient soil conservation strategies for the study area.

Keywords

Soil conservation, gully erosion, Ethiopian highlands, sediment concentration

Simulating the Impacts of Retention Basins on Erosion Potential in Urban Streams using SWAT

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Abstract

Urbanization typically has detrimental impacts on stream bank stability due to increased erosion potential. Studies have indicated that detention facilities designed to control large runoff events do little to address this problem and may exacerbate the problem. Recent studies by the City of Austin, Texas have shown that smaller retention facilities designed to address water quality concerns may also reduce the erosion potential associated with development. This study employs the new urban BMP routines in SWAT to examine the effects of retention volume and draw-down rate on excess shear. Three different levels of development intensity were simulated for 23 years with differing retention volumes and drawdown rates. Excess shear was computed for each model run based on four different median particle sizes, 12.5, 19, 25.4 and 38 mm and compared to excess shear in an undeveloped, stable channel.

Increased retention volumes reduced excess shear for 19, 25.4 and 38 mm median particle sizes but increased excess shear for 12.5 mm median particle size because the flow rate associated the with draining retention basins was greater that the flow rate associated with the critical shear. Increasing drawdown rates decreased excess shear for 12.5, 19, 25.4 mm median particle sizes but increased excess shear for the 38 mm median particle size because the retention basins were full more often, creating bypass flow with rates exceeding the critical shear for this particle size.

The influence of glacial lake outburst floods on water discharge in the headwater of the Aksu catchment: an assessment using the hydrological model SWIM

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Abstract

The upper Aksu catchment of the Kumarik River is the most important source of water discharge to the Tarim River, NW China. Changes to the catchment due to climate change, may have far reaching consequences downstream. Modelling its water resources is important for the future water availability of the intensively cultivated river oasis downstream and the Tarim River as the principle water resource of the Xinjiang Uyghur Autonomous Region, China. The Soil and Water Integrated Model (SWIM), a synthesis of the SWAT and the MATSALU model codes with further development since the late 1990s, was calibrated to the outlet station Xiehela on the Kumarik River. We show that the catchment's annually reoccurring Glacial Lake Outburst Floods (GLOFs) of the Merzbacher Lake, Kyrgyzstan have a significant effect on river discharge at the Xiehela station and the model performance. This unique hydrological phenomena adds to the difficulties of modelling this high-mountain, heavily glaciated catchment. Hydrological modelling supports the investigation of the Merzbacher Lake GLOFs by providing natural catchment discharge during GLOF periods and at the lake's ungauged catchment. Results show that model performance can be improved both in terms of efficiency and in the total deviation in the water balance when the GLOF periods are excluded. Further analysis uses the simulated discharge as the catchment's natural discharge during the GLOF periods. This is used to derive a general flood-baseflow relationship and to estimate flood volumes, a proxy for the Merzbacher Lake volume.

Improvement and Application of SWAT Model for Irrigation Water Supply in Agricultural Reservoir of South Korea

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Abstract

The Soil and Water Assessment Tool (SWAT) is a well-developed, physically based continuous, long-term, distributed-parameter model. However, using the study case of an agricultural reservoir watershed, it was shown that current model versions are not able to appropriately evaluate the reservoir performance in such system when it worked as a multiple purpose to supply water for irrigation and environmental flow. The aim of this study is to improve the reservoir module in SWAT2009 version for correctly simulating the multiple water supply system of agricultural reservoir based on water level. The improved SWAT model simulate the reservoir operation by calculated irrigation water requirements (4744.7 ha) and main hydrological processes at the same time. The improved SWAT model was modified to adjust the references to the specified release and the model then made the release determination for each period. The definition of releases here includes the irrigation water, environmental flow and spillway from the reservoir, losses through evaporation and pool seepage in the reservoir. Using daily water level at three reservoirs (Gosam, Geumkwang, and Madun) and streamflow at two water stage stations (AS and GD) data, the improved SWAT model was calibrated (2006-2012) and validated (1998-2005) for a 363.7 ㎢ Anseong-cheon agricultural watershed in South Korea. On a daily basis, the reservoir operation results at this period appear reasonable. However, several factors should be considered when comparing the water levels, and it can be inferred that a number of errors are likely to occur due to manager operation error, the uncertainty of inflow data, and the pool elevation storage curve. The evaluation criteria of calibration and validation results were assessed using five objective functions for streamflow, including the Nash-Sutcliffe efficiency (NSE). The average NSE during calibration and validation periods were 0.74 at AS and 0.72 at GD (watershed outlet), respectively. To enable adaptation due to multiple water supply of agricultural reservoir as a widely accepted environmental flow release, decision makers require quantitative results for the establishment of adaptation strategies. Detailed application of the improved SWAT model and its results for the adaptation of agricultural reservoir operation to the multiple water supply will be discussed.

Keywords

Agricultural Watershed; Environmental Flow; Irrigation Water Requirement; Multiple Water Supply; Reservoir Operation; SWAT

Acknowledgements

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SWAT Application in Low-Gradient Coastal Plain Landscapes

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Abstract

Low-gradient coastal plain watersheds present unique challenges for watershed modeling. Broad low-gradient floodplains with considerable in-stream vegetation contribute to low-velocity streamflow. In addition, direct interaction between streamflow and surficial aquifers must also be considered. Here we examine several efforts that have involved application of the Soil and Water Assessment Tool (SWAT) to the Little River Experimental Watershed (LREW) in South-central Georgia within the Coastal Plain region of the US. Specific objectives include: 1) Examine prior attempts to model the hydrology and water quality of the LREW; 2) Summarize the outcomes of prior SWAT modeling attempts; 3) Identify consistent weaknesses in the computer simulations; and 4) Propose guidance for future applications. Climatic and hydrologic data from the LREW were used. Results indicate streamflow timing and groundwater contributions can be managed through parameter adjustment. While calibrated SWAT simulations provide acceptable water balances, discrepancies remain between simulated and observed streamflow for periods where large rainfall events occur during seasonably dry summer conditions. SWAT revisions, including the grid version of SWAT, better landscape differentiation, parameter variation throughout the year, differentiation of slow-return and fast-return groundwater flow, and sub-daily time steps, should yield improved representation of hydrology within Coastal Plain watersheds.

Keywords

Groundwater, streamflow, hydrology, watersheds

Evaluating the simulation of groundwater-surface water interactions in SWAT: comparison with other simulation tools and field observations

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Abstract

At the river bed there are continuous interactions between the ground water and the surface water: the river is losing or gaining water, depending on the location of the water table, the river bed and the level of the water in the river. Rivers are gaining when groundwater discharges occurs, while in disconnected rivers - when the groundwater level is below the river bed - seepage loss to the ground water can be significant, depending on the river bed material and the hydraulic head. These processes are governed by the head difference between the river and the shallow aquifer in the riparian zone. In SWAT, these head differences are not computed: the groundwater discharge is simulated by means of the hydrological processes in the river basin, while seepage in the river bed is governed by the hydraulic conductivity of the river bed. With the current version of SWAT, it is hence not possible to simulate processes where rivers (seasonally) alternate from gaining rivers to loosing rivers. In addition, both processes (gaining and loosing) can be simulated simultaneously, which does not reflect reality.

In this study, the schematizations of overland flow, groundwater flow and channel flow in different catchment simulators (SWAT, WETSPA, MOHID and MIKESHE) are compared and discussed. Different models are presented for the Zenne river basin and the results regarding the groundwater-surface water interactions are compared with results of tracer test, whereby temperature sensors are used to estimate the flux in the river bed. The results are further compared with estimations obtained from baseflow separation techniques.

From the temperature sensor data in a winter field campaign it can be seen that there is a significant flux from the groundwater to the river.

As a conclusion it can be stated that it is important to investigate the ground water -surface water interaction during the modeling process as this may have affect the interpretation of the model results.

Estimated calibration parameters in SWAT model for Andean watersheds

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Abstract

In recent years, the International Center for Tropical Agriculture (CIAT) has supported the development of Payment for Ecosystem Services (PES) schemes through hydrologic and economic analysis, investigating the impacts of current and potential land use in Latin American watersheds, especially in the Andean region. These research projects have employed the SWAT model, given its capacity to provide reliable information about the contribution of different areas in the watershed to overall water production. Andean watersheds are characterized by significant landscape diversity in terms of soil type, land use and relief. These factors, when combined with changes in climate along the altitudinal gradient, create different hydrological responses within the same basin. This diversity presents difficulties for hydrological models aimed at simulating stream flow behavior. Despite these challenges, correct calibration of the SWAT model makes it possible to achieve accurate results, allowing for the application of this model in Andean watersheds.

This article presents the results of a sensitivity analysis of pertinent parameters on stream flow for ten basins where the SWAT modeling tool has been utilized: River Cañete in Peru; River Quijos in Ecuador; River Guavio, Fuquene Lake, Riogrande II Reservoir, River La Fe, River Piedras Blancas and River Tunjuelo in Colombia; Rivers Valles and Xilitla in Mexico. The diverse range of basins covered in this analysis enabled the identification and quantification of parameter default range values and extrapolation of these values to cover the entire Andean region. These default ranges will provide a useful starting point for more detailed analysis of Andean watershed environments.

Keywords

Hydrological model; water yield; calibration; parameters; Andes basins; SWAT model

Uncertainty Issues in SWAT Model Calibration at Cirasea Watershed, Indonesia

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Abstract

SWAT Model is a hydrological model which needs the detail parameters in the process that includes specific information on climate, soil characteristics, topography, vegetation, and land management practices. The model is phisycally based which capable to simulate the physical processes that related to water movement, sediment, plan growth, nutrient cycles and so on. Thus, many of uncertainty factors that will affect the SWAT model, especially on calibration process. In general, calibration is done automatically using the facilities that provided by SWAT model like automatic calibration or another model, SWATCup or SUFI-2 (multi-site semi-automated inverse modeling routine). The use of automatic calibration would be helpful if the model is applied on large scale. On the application of small scale, manual calibration will be more helpfull in better understanding the various fators of uncertainty in hydrological models. In addition, users can also control which parameters are more influential to the model with respect to the hydrograph pattern. The aim of this study is to understand the process of manual calibration and the uncertainty factors in hydrological model using SWAT. This model is a case study on CIrasea Watershed of 6.832 ha is located in the upstream Citarum Watershed, West Java Province, Indonesia. Daily simulations both rainy and dry season gaves satisfactory results to the discharge hydrograph.

Keywords

SWAT, calibration, uncertainty factors, discharge hydrograph.

Model calibration and uncertainty analysis for discharge in the Kunwari River Basin, India using sequential uncertainty fitting

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Abstract

The Kunwari river basin is one of the agricultural dominant river basins of the country and needs effective management of water resources for sustainable agriculture due to anthropogenic activities and climate change. The distributed hydrological model (SWAT) is effective tool for evaluation of water resources in the basin. Soil and Water Assessment Tool was chosen to set up the Kunwari river basin modeling. Sequential Uncertainty Fitting (SUFI-2) is used for model sensitivity, calibration and uncertainty analysis, which is one of the integrated programs with SWAT in the package SWAT-CUP (SWAT Calibration and Uncertainty Programs). When the model is set, the calibration was performed for the period from 1987 to 1999 by keeping 3 years of worm up period and validated for the next 5 years from 2000 to 2005.Results of model run indicated that the p-factor was 0.72 and the r-factor was 0.55 in calibration while the *p-factor* was 0.49 and the *r-factor* was 0.56 in validation period. When values of *p-factor* and *r-factor* are reached the accepted limits, further goodness of fit can be quantified by the coefficient of determination (R^2) and Nash–Sutcliffe coefficient (NS) between the observed and the final best estimated values. The results indicated that R^2 and NS were 0.78 and 0.76 in calibration, whereas R^2 and NS were observed as 0.73 and 0.72 during validation period. The results of model run for calibration and uncertainty analysis were found satisfactory.

Keywords

Sensitivity analysis, uncertainty analysis, sequential uncertainty fitting, discharge, SWAT model, calibration and validation

Which parameter complexity is required for a sound simulation of agricultural river basins? Investigating SWAT model sensitivity to agricultural land cover and crop rotation parameterizations

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Abstract

A suitable representation of agricultural land cover is one of the large challenges when setting up a SWAT model. Especially in large, heterogeneous catchments - which are intensively used for agricultural production - information regarding the types and locations of agricultural crops is crucial for a sound simulation of water cycle, nutrient losses and crop yields. Crop rotations that relocate the crops from year to year may complicate that issue and extend it to the temporal dimension. Modelers usually struggle with a lack of those data as well as with finding a suitable degree of generalization that satisfies the modeling and simulation quality demands.

Hence, it is important to know how different degrees of parameter generalization of the spatial and temporal crop distribution influence the simulation results. Therefore multiple models of the Striegis river catchment in Central Germany were set up. For each model common available agricultural statistics and expert-knowledge based crop rotation information were used in different degrees of detail to parameterize agricultural land within the catchment. The different model setups were analyzed considering the simulations results of streamflow, nutrients, sediments and crop yield. Furthermore the sensitivity of SWAT regarding crop rotations was investigated at catchment as well as at HRU level.

The recommendations derived from the study results can help modelers to assess the uncertainties resulting from different spatial and temporal parameterization possibilities of agricultural land cover. The study results could also help to improve model setups used for scenarios of land cover change (e.g. bioenergy cropping scenarios).

Developing drought assessment tool for India under intensive groundwater irrigation: a SWAT-based approach

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Abstract

Drought is a common natural phenomenon and may have extensive impacts on agriculture and environment. However, it is difficult to characterize these impacts in intensively irrigated agricultural areas using conventional drought-index approach since during the calculation of drought indexes it is typical that no explicit consideration is given to the irrigation activity. India is a country with intensively irrigated agriculture. The irrigation in India heavily depends on groundwater resources, and groundwater overdraft has become a major environment concern. In a study launched recently, the Soil and Water Assessment Tool (SWAT) was selected as major modeling tool for drought assessment for India. As a key step in model development, an attempt was made to simulate the groundwater irrigation activities in India using recently developed cropping pattern and groundwater irrigation inventory data. The model was validated using total water storage variation data derived from the Gravity Recovery And Climate Experiment (GRACE). The model validation results indicated that the developed SWAT model can replicate the pattern of total water storage variation, especially the depleting trend in northwest India detected by GRACE, adequately well, and thus is promising to serve as a modeling tool to explore the linkage between the agriculture and groundwater under drought conditions in future work.

Building a high-resolution hydrological model of Europe

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Abstract

The natural cycle of water availability in Europe is continuously coming under threat from a variety of different pressures like droughts and floods, water scarcity, and pollution. All these increase the vulnerability of the freshwater ecosystems and societies. Landuse change, water abstraction, and climate change are human-induced changes that alter the natural flow regimes in water bodies. To better deal with the future situation a detailed and high-resolution hydrological model of the continent is essential. This paper demonstrates the building and calibration of an integrated hydrological model of Europe using the SWAT program where crop yield and water quality are also considered. The hydrological-crop model simulates water resources at subbasin level and monthly time intervals. The use of such a model enables comprehensive examination of integrated system behavior through physically-based, data-driven simulation. In this article we discuss issues with data availability, calibration of large-scale distributed models, and outline procedures for model calibration and uncertainty analysis.

Nutrient Delivery from the Mississippi River to the Gulf of Mexico and Effects of Cropland Conservation

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Abstract

Excessive nutrients transported from the Mississippi River Basin (MRB) have created a hypoxic zone within the Gulf of Mexico, with numerous negative ecological effects. Furthermore, federal expenditures on agricultural conservation practices have received intense scrutiny in recent years. Partly driven by these factors, the USDA Conservation Effects Assessment Project (CEAP) recently completed a comprehensive evaluation of nutrient sources and delivery to the Gulf. The modeling framework used in the CEAP Cropland National Assessment or "Cropland CEAP" consists of the Agricultural Policy/Environmental eXtender (APEX) and Soil and Water Assessment Tool (SWAT) models. This CEAP modeling framework was successfully calibrated for flow, sediment, and nutrients at 38 sites and validated at an additional 17. Simulation results indicated that cultivated cropland was the dominant source of nitrogen (N) and phosphorus (P) to both local waters and the Gulf, but this was not true for each water resource region within the MRB. In addition, the results showed that point sources remain significant contributors of P loads, especially in the Tennessee and Arkansas/Red River Basins where point source P loads exceeded those from cultivated cropland. Similarly, urban nonpoint sources were significant nutrient sources. The Upper Mississippi, Lower Mississippi, and Ohio Basins contributed the largest amounts of nutrients delivered to the Gulf. The high delivery areas near the Mississippi River main stem, from which 87% of N and 90% of P was predicted to reach the Gulf, also coincided with elevated nutrient yields to local waters. Conservation practices established on agricultural lands within the MRB were predicted to have reduced nutrient loads to the Gulf by 20% as compared with a no conservation condition. The results indicate the importance of targeted implementation of conservation practices and consideration of local water and/or Gulf impacts depending on program goal(s). The present application illustrates the value of the Cropland CEAP modeling framework as a useful, science-based tool to evaluate pollutant sources and delivery and effects of agricultural conservation practices.

Emerging Contaminant Soil Fate Model Subroutine Development for SWAT

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Abstract

A new soil module to update and expand the current one, targeted specifically onto pesticides presently in SWAT, is the subject of an ongoing development project at the US Department of Agriculture-Agriculture Research Service Grasslands, Soil and Water Research Laboratory, Temple, TX USA. The objective of the project is to formulate a comprehensive, process-based mass-balance theory, advection-diffusion transport model with reaction applicable to pesticides as well as emerging contaminants (EmCons) which include antibiotics, hormones, metals, polychlorinated biphenyls, nano-particles, etc. All these and more may arrive at or be directly placed onto or under shallow surface layers of soils on watersheds. A novel modeling approach built around the strongly layered structure of surface soils in the meter+ depth was named the G-Box. The conventional, simple, transparent and useful box-modeling approach popular in environmental chemical fate modeling was adopted but, selectively modified so as to handle the multitude of in-layer diffusive-like transport processes needed in a realistic soil chemical model. Hence the letter "G" for gradient [diffusive], in the model name. The principal of "continuity of flux" was used to mathematically connect the adjacent boxes and maintain the law of conservation of mass. It allows for easy numerical changes, with depth, of soil layer process parameters. A series of interconnected, transient ordinary differential equations is the result. They are soluble by the well know 4th order Runge-Kutta numerical integration method. The HRU-focused, layered soil boxes receives EmCon inputs from the adjoining atmospheric boundary layer, has lateral seepage out the sides, plant water uptake, downward water infiltration to a deeper infinitely thick sub-layer sink. A total of eighteen processes are currently included. Mirex, a historic pesticide with well-established physico-chemical properties, will be used to illustrate some simulation capabilities of the new module.

The future evolution of SWAT and APEX

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Abstract

SWAT and APEX are respectively large and small watershed simulation models coded in Fortran. Since their original development, Fortran has been through several cycles of development. It now provides functionality originally restricted to languages like C, designed to communicate directly with the operating system and hardware. One can now use an object-oriented style of programing in Fortan, including inheritance, run-time polymorphism and overloading. In recent years SWAT has been rewritten to use some of these new Fortran features, and development continues. Some newer methods have also been incorporated into APEX, however it is currently undergoing a complete revision utilizing many of the newer programing features. With these new programing paradigms the developers of both SWAT and APEX are working to make communication between the two models seamless. It is intended that their evolutions will converge while maintaining their distinctive features and capabilities – to preserve their brands.

SWAT plant growth modification for improved modeling of vegetation dynamics (perennials) in the tropics.

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Abstract

Originally designed more for temperate regions, SWAT must be critically examined for its appropriate use in tropical watersheds. One major concern is the simulation of perennial tropical vegetation due to the absence of dormancy. While for temperate regions SWAT uses dormancy to terminate growing seasons of trees and perennials, seasonality in the tropics (wet and dry season) can only be represented by defining date or heat unit specific “plant” and “kill” operations which are fixed for every year of simulation. We will discuss these shortcomings and present an alternative approach to automatically provoke annual growing cycles based on changes in soil moisture. Furthermore, we propose a logistic LAI decline function approaching the user-defined minimum LAI instead of using the default function, which is linearly proportional to the increase of heat units and is not considering the minimum LAI. The modified SWAT model was tested based on MODIS LAI and ET data for the Santa Maria / Torto watershed in Central Brazil, covered mostly by Cerrado (savanna) vegetation. Our model results show that the modified model can reasonably represent seasonal dynamics of the Cerrado biome. However, since the proposed changes are process-based but also allow flexible model settings (e.g. plant growth starts based on a soil moisture threshold adjustable for plant / land cover types within an adjustable time frame), we strongly believe that the modified plant growth module can be useful for many SWAT modelers, especially for those working in the tropics.

Spatial Integration of SWAT, MODFLOW, and RT3D for Simulation of Hydrologic and Water Quality Processes in Irrigated Agricultural Watersheds

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Abstract

Watershed models are valuable tools in assessing surface and subsurface water quantity and quality impacts due to land management practices in watersheds of varying scale and complexity. However, surface water models typically lack sufficient detail in groundwater systems to accurately describe heavily irrigated agricultural or groundwater driven watersheds. Similarly, groundwater models typically lack important land surface processes like plant growth, nutrient cycling, and overland flow to stream networks. In this study, we present a model that is capable of simulating both land surface and subsurface flow and nutrient transport through the coupling of SWAT with the variably-saturated groundwater flow model, MODFLOW-UZF, and a variably-saturated groundwater solute reactive transport model, UZF-RT3D. Overland flow and stream routing is handled by the SWAT subroutines, while fluxes of water and chemical species within the subsurface and associated loadings to and from surface water are handled through the subroutines of MODFLOW-UZF and UZF-RT3D. Also, secondary SWAT pre-processing algorithms are used to distribute spatially disaggregated HRUs to improve representation of watershed heterogeneity. The accuracy and usefulness of the SWAT-MODFLOW-RT3D model is demonstrated through applications to multiple study basins within the United States wherein groundwater is a significant contributing factor to surface water processes.

Keywords

SWAT, MODFLOW, watershed modeling, groundwater, groundwater solute transport, irrigated agriculture

Moulding SWAT model for Chinese Qingjiang river for rainfall-runoff simulations

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Abstract

SWAT model is a typical distributed hydrological model developed by the U.S. Department of Agriculture.

As the model was originally designed for North America river basins, the databases were designed to suit the situations there. Therefore, to apply it in China, the databases, mainly including soil database and weather generator, have be modified to suit Chinese data standards.

This paper took Chinese Qingjiang river basin for case studying, discussed how to set up and modify the soil database and weather generator to suit Chinese situation, and use the model to perform monthly and daily runoff simulations.

For soil database establishment, empirical formula on soil infiltration rate was used to divide Chinese soils into four hydrologic soil types defined by the US standards. For example, the SPAW program was used to estimate the soil water characteristic parameters (such as soil bulk density, saturated hydraulic conductivity and effective water capacity), by using measured organic carbon, sand and clay contents.

For establishing weather generator, the observed daily rainfall, maximum/minimum temperature, solar radiation, and wind speed from five meteorological stations in the basin were used to calculate the corresponding monthly averaged values by using PcpSTAT and Excel programs. And the Dew02 program was used to estimate the monthly averaged dew point temperature by using daily maximum/minimum temperature and relative humidity data.

Nash-Sutcliffe efficiency coefficient (E_{NS}) was used to evaluate the accuracy of the simulations. Monthly averaged flow data from 1989 to 1995 were used for monthly simulation, whereas the data from 1989 was taken for model warming up, the data from 1990 to 1992 were used for calibration (where the calibration accuracy E_{NS} is 0.89) and the data from 1993 to 1995 were used for validation (where the validation accuracy E_{NS} is also 0.89). Daily simulations were performed by using daily flow data from 1997 to 1999. the Year 1997 was taken as the warm-up year, the year 1998 as the calibration year (E_{NS} =0.77), and 1999 as the validation year (E_{NS} =0.73). According to the results, the SWAT model moulded for Chinese Qingjiang river basin showed satisfactory simulation accuracies, therefore, will be an effective tool to be applied in the water resource management in the basin.

Keywords

SWAT model; Soil database; weather database; Qingjiang River basin

Spatial representation of evapotranspiration in the Mara basin: results derived from the SWAT model and remote sensing products

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Abstract

Next to precipitation, evapotranspiration (ET) is a crucial as well as dominant component in a river basin water balance. Hence, it is vital to explore the spatial variability of ET across different cover types in a basin. However, the measurement of ET is often described as time and labor consuming and thus, hydrological models are considered as an alternative. Physically based and process-oriented models simulate a series of physical and plant physiological processes controlling ET. Therefore, we applied the Soil and Water Assessment Tool (SWAT, version 2012) to simulate hydrological process in the Upper Mara basin. Firstly, the SWAT model was built and then calibrated and validated in this data scarce tropical watershed for the period of 1980-1992. Secondly, the SWAT estimated ET fluxes were analyzed at various spatial scales. In addition, the ET spatial variability was evaluated using remote sensing products from MODerate Resolution Imaging Spectroradiometer (MODIS). As noted in the analysis, the SWAT model often did not give realistic spatial patterns of ET at the HRU level that is consistent with the landcover types. In contrast, the results from MODIS ET showed spatially consistent ET variability which reflected the landscape heterogeneity. In conclusion, the reasonable SWAT model's skills in simulating discharges with calibrated parameters, might not guarantee similar performance for other water balance components such as ET. Thus, the use of spatially distributed ET estimates from remote sensing data during calibration and validation processes could potentially improve the prediction abilities of hydrological models in the data scarce Upper Mara basin.

Keywords

Mara basin, SWAT, Evapotranspiration, MODIS, spatial variability

Online Supporting System Flood Warning for VU GIA Watershed, Quang Nam Province, Vietnam

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Abstract

Vu Gia watershed is located in the Central Vietnam where hurricanes represent a constant natural threat to human lives and physical infrastructure. Hydrological monitoring is considered as an effective tool to respond to high flood events by preventing and mitigating damages. The purpose of this study was to conduct and perform hydrological modeling to determine areas prone to be flooded during high rainfall events in the upstream Vu Gia watershed. The methodology involved: hydro-climatic data base building, a detailed Digital Elevation Model (DEM), a land use cover, and a soil map of the basin. With all this data, the SWAT model (Soil and Water Assessment Tool) was used to predict discharge values. These discharge values were used, along with the DEM, to predict flood hazard areas in the downstream of Vu Gia watershed floodplains. This procedure was made using the HECRAS model (Hydrological Engineering Center-River Analysis System). Finals results show the exact location of areas with high, moderate and low risk to be flooded at specific high flood events. The results also provided the location of critical areas, so that an early warning system can be located. Additionally, as a part of this study, valuable information was provided to at-risk residents about how to prevent and mitigate the effect of flood-related damages in low land areas of the Vu Gia watershed.

Modeling wheat yield gaps in Russia using the SWAT model

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Abstract

Significant increases of crop yields are necessary to satisfy growing global demand for agricultural products. Globally important hotspots of large crop yield gaps are located in Russia, where crop productivity falls far short of regions with comparable natural suitability for crop production. Particularly, insufficient soil and fertilizer management are the proximate causes for low crop yields in Russia. Unfortunately, the magnitude and spatial distribution of crop yield potentials and yield gaps of wheat in Russia are unknown. We applied the Soil and Water Assessment Tool (SWAT) to simulate crop yield potentials and yield gaps under rainfed conditions in European Russia. We used the Sequential Uncertainty Fitting Program (SUFI-2) for model calibration and validation based on provincial statistics of wheat yields from 1998 to 2006. The SWAT model performed well for 21 of 31 important wheat growing provinces. The calibrated SWAT model simulated an average wheat yield gap of 2 t/ha (range 0.6 t/ha – 2.5 t/ha), or ~40% (range 12% - 64%) of wheat yield potential [M1] under rainfed conditions. Most provinces inside the black earth belt have low wheat yield gaps under rainfed conditions because of higher input levels of nitrogen and phosphorus. Water-limited wheat yield gaps were largest for the Northern provinces outside the black earth belt of European Russia, while frequent droughts in the Volga region limit wheat yield potentials under rainfed conditions. Our results suggest considerable potentials for increasing wheat production in European Russia, if farm-level improvements in fertilizer management contribute to closing yield gaps. Yet, structural impediments such as difficult access to capital and markets as well as few investments in research currently impede management improvements.

A large-scale SWAT application for investigating crop production potentials in Russia, Kazakhstan and the Ukraine

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Abstract

Food scarcity is one of the main issues of the 21th century considering global dynamics such as population growth, increasing cultivation of bioenergy plants and changing nutrition habits. The countries of the former Soviet Union represent one important region to satisfy future increases in cereal demand. In particular, Russia, Kazakhstan and Ukraine hold great potentials to increase cereal production due to large areas of abandoned cropland as well as high crop yield gaps. We aim to quantify the biophysical cereal production potential of these countries by applying SWAT for major sea basins. The corresponding three models (Caspian Sea and Aral Lake Model, the Black Sea Model and the Arctic Ocean Model) will be calibrated on existing cereal yield statistics. We will concentrate on SWAT's capabilities for large-scale simulations, accounting for climate change and land re-cultivation scenarios to assess management options for increasing cereal production from cropland expansion and yield increases. Our analysis will also quantify tradeoffs between the scenarios on selected ecosystem services in a further stage. We will validate the model results using down-scaling strategies for comparison with representative regional models, which may also involve the farm scale. In our presentation, we will introduce the project and discuss the large scale sea basin models regarding their representativeness on that scale in general and more specifically for the purpose of yield modeling. Also, demand, availability, and quality of required datasets will be discussed as well as strategies for a meaningful selection of study regions in accordance to the downscaling and calibration objectives.

Modelling water fluxes and suspended sediments in the Garonne catchment (France)

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Abstract

The Soil and Water Assessment Tool (SWAT, 2009) was used to simulate the discharge and suspended sediment transport at daily time step within the Garonne River Catchment (50 000 km2, at outlet in Tonneins). The model SWAT was applied to evaluate the catchment hydrology and sediment associated with human activities using the daily observed discharge data of 20 stations and suspended sediment (SS) of existing control station along Garonne River based on climate data of chosen 39 meteorological stations all over the catchment for 20 years (January 1990- December 2010). The daily observed discharge and SS data for 10 years (1991-2000) were used for the calibration and 10 years (2001-2010) were used for the validation of the model. Simulated daily discharge values matched well the observed values; the results are satisfactory and also acceptable for monthly flow of Garonne sub-catchments compared to the outlets located closed to the chosen observed discharge stations. The mean annual precipitation estimated by the model for 20 years is 950 mm. 52% of precipitation is lost by evapotranspiration and the rest contributed to rivers through groundwater flows and surface runoff. Simulated mean water yield for the whole simulation period amounted to 390 mm, comparable to the observed value (Garonne at Tonneins) 335 mm. According to the simulated specific daily flow, the mains contributors of water flow during rainfall events are the sub-catchments located in the upstream part of the Garonne in the Pyrenean mountains and in the upstream part of some Garonne's tributaries, particularly from Massif Central mountains.

Modelling of climate change impacts on river flow regime and discharge of Danube River considering water management effects

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Abstract

The Danube River basin (~ 800,000 km^2) is the second largest river basin in Europe. As a highly regulated river (80% of the length) the Danube is strongly influenced by water management effects. Large dams might not only interrupt the river and habitat continuity, but have an important effect on the natural river flow regime. The Iron Gates I and II reservoirs alone have a total volume of 3.2 billion m^3 with a total length of 270 km and among hydropower generation are also used for the flow regulation on the Danube River.

The goal of this study is to gain scenario information about the actual river flows in the future. The natural discharge as well as reservoir management in the Danube basin needs to be considered when simulating potential impacts of climate change.

For this study the eco-hydrological watershed model SWIM was applied for the Danube basin using a special water reservoir management module which accounts for the major reservoirs in the basin. By the implementation of the water reservoir management module additional a better representation of the actual river levels is pursued. After calibration and validation of the model, this study uses a set of 14 high-resolution climate change projections performed by several state-of-art GCMs and RCMs, all based on the IPCC-SRES-A1B emission scenario, from the ENSEMBLES project (EU FP6). They serve as meteorological drivers for the SWIM model to simulate the future development of river runoff under scenario conditions. The results are used to quantify the range of predictive uncertainty and to allocate robust trends.

Using SWAT and an optimization algorithm for quantifying ecosystem services and trade-offs in large river basins – Challenges and potential solutions

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Abstract

The presentation will point out challenges and potential solutions with regard to quantifying ecosystem services and trade-offs by using SWAT and optimization algorithms in large river basins. The procedures are aiming at linking SWAT to an optimization algorithm (NSGA-2) in order to identify numerous optimal land use configurations and to analyze trade-offs between different goal functions (e.g., low flow, water quality, food and bioenergy crop production, etc.). An effective and reasonable setup and application of such procedures is not an easy task: Considering process complexity and scale-related needs to generalize input parameter and – often related to that – suitable monitoring data for process understanding, model calibration and evaluation is crucial. Hence, before carrying out the optimization it is worth analyzing historical time series to detect possible interference and trends of climate data, streamflow, and water quality. Examples for partly oppositional trends (streamflow, water quality) in the case study region in Central Germany will be shown. The trends are calculated by both commonly used and innovative new statistical methods. Moreover, methods to cope with large reservoirs in the basin (that act as interference in the hydrological cycle) as well as single- and multi-site calibration strategies will be discussed. Although first successful simulations were carried out in a smaller experimental watershed of around 320 km², open questions will be discussed about the design of multi-optimization strategies for larger river basins (current study area Saale River basin 23,000 km²) with spatially varying problems and goal functions.

Assessment of Climate Change Impact on Future Turbidity Current Regimes in Soyang Lake with CE-QUAL-W2 Considering SWAT Inflows

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Abstract

This study is to evaluate the future climate change impact on turbidity current regimes for a 2,694.4 km^2 Soyang Lake watershed in South Korea using SWAT (Soil and Water Assessment Tool) watershed model and CE-QUAL-W2 reservoir water quality model. The SWAT model was calibrated and validated using 6 years (2005-2010) daily reservoir inflow data and monthly stream water quality (SS, T-N, and T-P) data. The average Nash-Sutcliffe efficiency for reservoir inflow was of 0.75 and the average R^2 for water quality (SS, T-N, and T-P) were 0.72, 0.60, and 0.20 respectively. For the reservoir of 2.9 billion m^3 storage capacity, the CE-QUAL-W2 model was calibrated and validated using the measured monthly reservoir water quality data (water temperature, SS, T-N, T-P, and chl-a) by using the SWAT simulated results. Results of CE-QUAL-W2 model showed a good agreement with the field measurements of water balance, water temperature and turbidity using linkage of the SWAT model results. For the future climate change scenario, the MM5 RCM (Regional Climate Model) data were downscaled for FFS (foreseeable future scenario, 2011-2040), MFS (mid-term future scenario, 2041-2070) and LFS (long-term future scenario, 2071-2100) using the ANN (Artificial Neural Network), Dynamic Quantile Mapping and Stochastic Typhoon Simulation methods. Under the above future impact on reservoir inflow, the reservoir turbidity current was projected using CE-QUAL-W2 model. The results showed that the reservoir turbid current would stay longer in metalimnion due to thermal stratification of future flood year.

Keywords

Climate Change; RCM; SWAT; CE-QUAL-W2; Turbidity Current Regimes

Acknowledgements

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MEST) (No. 2012-0008716).

On targeted implementation of nonpoint source pollution control plans: enhancing the optimal design using a mixed discrete-continuous multiobjective genetic algorithm

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Abstract

Implementation of nonpoint source (NPS) pollution control strategies at the watershed scale hinges on abating pollutant movement from the landscape to water bodies at minimum cost. This study presents an integrated simulation-optimization approach for targeted implementation of agricultural conservation practices at the watershed scale. Previous optimization studies of conservation practices have used binary representation of nonpoint source pollution controls, even though many could be better characterized as continuous variables. In this study, a novel discrete-continuous decision variable, also known as mixed-variable, representation was used to enhance the versatility of the approach by evaluating more options during the search process. Application of the proposed framework in a predominantly agricultural watershed in the Midwestern United States indicated that the optimal suite of conservation practices from the mixed-variable NSGA-II was more effective in meeting water quality targets at lower costs. However, optimization of mixed-variables was considerably more computationally demanding for assessing tradeoffs between environmental and economic factors. A hybridization method was developed in the context of nonpoint source pollution control practices to enhance the computational efficiency of the optimization procedure. As a result, the number of model simulations required for convergence to the Pareto-optimal solutions was reduced by 96 percent. The conceptual complexity and computational requirements of optimization-based approaches are impediments to their wider application for targeted implementation of NPS pollution control strategies. The methods and finding of this study address these issues and could result in a more effective implementation of management strategies at the watershed scale.

Climate change and agricultural development: Adapting Polish agriculture to reduce future nutrient loads in a coastal watershed

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Abstract

Currently, there is a major concern about the future of nutrient loads transported into the Baltic Sea from Polish rivers because they are main contributors to its eutrophication, discharging 24% of total nitrogen and 37% of total phosphorus loads. Agricultural non-point sources are reported to have the highest share in observed nutrient loads. The aim of this paper is: (1) to quantify the effects of future climate, land cover, and management changes under multiple scenarios up to the 2050s, and (2) to test future efficiency of adaptation measures (BMPs), in the Reda watershed, a small (482 km2) agricultural coastal area in northern Poland. The SWAT model was applied to assess the current state of the system, and to quantify effects of future changes under multiple scenarios. The model was calibrated and validated against the observed daily discharge data and against bi-monthly sediment, N-NO3 and P-PO4 loads. Its performance was generally good, especially for discharge and N-NO3 simulation, while it was worse for P-PO4 in the validation period. The future scenarios consisted of changes in climate, population and urban land cover use. On top of these changes, two agricultural scenarios were developed: one assuming spontaneous development of agriculture (the Business-As-Usual scenario, BAU) and the second one its rapid intensification following the Danish model (the Major Shift in Agriculture scenario, MSA). The combined effect of climate and land use change on N-NO3 and P-PO4 loads yielded 20-60% and 24-31%, respectively, depending on the intensity of future agricultural usage. According to the MSA scenario, future crop yields would be significantly higher, but at a cost of a great deterioration of water quality. The urban sprawl represented in the model by an increased area of residential land cover did not cause visible effects on water quality, whereas climate change caused an increase in runoff and in consequence in nutrient loads by ca. 20%. Adaptation measures tested in the model were selected with stakeholder participation and concerned reduced fertilization in risk areas (RA), using vegetative cover in winter and spring (VC), buffer zones (BZ) and constructed wetlands (CW). The masure VC would be a very efficient way to reduce future P-PO4 loads so that they are lower than levels observed at present. However, even the best combination of all measures applied simultaneously would not help to remediate negative effects on N-NO3 loads caused by climate change and agricultural intensification.

Modelling bank erosion and sediment transport and validating with field measurements

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Abstract

Field and modelling studies show that bank erosion contributes considerably to the total sediment budget in lowland catchments. Previous studies on modelling sediment transport and bank erosion were carried out mainly at meso-scale and mainly focused on in-stream processes. Therefore, impact of catchment managements on sediment transport in streams cannot be evaluated. The study aims to model daily flow, sediment mobilisation and sediment transport in the 486 km^2 Odense catchment in Denmark with the Soil and Water Assessment Tool (SWAT) model. Further to validate the modelled bank erosion with *in-situ* bank erosion measurements. *In-situ* bank erosions were measured using ca. 3000 erosion pins installed at 180 plots in 36 streams in the Odense catchment from October 2006 to April 2009.

SWAT model will be set up for the Odense catchment and calibrated for daily flow and sediment load. Subsequently, sediment from bank erosion and calculated bank retrieve in different streams from the model will be compared with *in-situ* measurements. The study provides insights to sediment source and related pollutants in the catchment and benefits future catchment management.

Keywords

Sediment, bank erosion, SWAT, erosion pin, catchment model, sediment routing

A generic algorithm for modelling benthic nutrient fluxes

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Abstract

In shallow aquatic systems, including river systems, benthic fluxes play a significant role of transformation, retention and elimination of nutrients from the water column. In the case of rivers flowing over gravel beds, the benthic processes are dominated by the interaction between biofilms and hyporheic flow. In most lowland rivers however, benthic processes are dominated by the exchange of solutes between the water column and a layer of freshly deposited, re-erodable and compacting sediments.

Although difficult to carry on, a large number of direct measurements of benthic fluxes in a variety of river systems have been obtained. They allow establishing a conceptual model of benthic processes in sediment accumulating rivers stretches. Thouvenot et al (2007, 2009) have translated it into a detailed diagenetic model, implemented in the Seneque/Riverstrahler model of biogeochemical processes in drainage networks. However the calculation scheme associated with this model, based on the analytical resolution of diagenetic equations, is numerically complex, as it requires solving implicit equations, making this module of the Seneque/Riverstrahler model rather expensive in terms of calculation time, and sensitive to certain extreme modelling situations.

Here we present a thorough analysis of the response of Thouvenot's model to the various constraints affecting benthic processes, primarily based on the concept of oxidant benthic demand. Based on this analysis, we propose a new alternative algorithm simplifying the calculation of the benthic fluxes, while complying with the rule of matter conservation. The algorithm is suitable for inclusion in any model of in-stream biogeochemical processes, including SWAT.

An Approach for Sub-Field Level Identification of Phosphorus Critical Source Areas in a Region Dominated by Saturation Excess Runoff

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Abstract

The identification of phosphorus critical source areas (CSAs) has become an important step in strategies to reduce nonpoint source phosphorus contributions to lakes and streams. Identification of these CSAs provides the basis for targeted mitigation and the efficient utilization of limited resources. A high resolution SWAT model was applied to Lake Chaplain's Missisquoi Bay Watershed, located along the border of the United States and Canada. The model contained a total of approximately 110,000 HRUs, with agricultural land uses modeled at the sub-field level. Because this region of the Northeastern United States is dominated by saturation excess runoff, an approach for adjusting the SCS curve number (CN) values based on the local compound topographic index (CTI) was incorporated into the model parameterization. The approach used the local CTI value relative to the probability distribution of the CTI to nudge the standard CN to a value between the antecedent soil moisture condition I and condition III values. After calibration and validation, the SWAT model was run for a 30-year period in order to identify the phosphorus CSAs throughout the watershed. The CSAs identified by the SWAT model were further validated through field visits by independent natural resource experts, resulting in greater confidence in the model. The model was then used to assess the benefits of targeted implementation of BMPs as well the potential impacts of climate change. The resulting sub-field level CSA map is currently being hosted online, providing natural resources planners, land owners, and scientists ready access to these data.

Modeling diffuse nitrate pollution transfer during flood events in an intensive agricultural catchment: the case of the Flumen River (NE Spain)

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Abstract

Nitrate pollution is the major concern in irrigated agricultural watersheds in general and in Europe after the introduction of the European Water Framework Directive in 2000. Non-point nitrate pollution takes place in river waters after agricultural irrigation through surface runoff, lateral and groundwater flow, in relation with the agricultural practices, soil, geomorpohological and meteorological characteristics of the watershed. The most important inputs of nitrate to the river occur during flood events in semi-arid environments. This work takes part in the EU AguaFlash project (http://www.aguaflash-sudoe.eu/), which tries to identify the relationships between agricultural land uses and changes of the river water quality during flood events.

In the River Flumen (1,500 km2, in Monegros region in Aragon, NE Spain) watershed, the SWAT model was applied from January 2009 to June 2011 for hydrology and nitrates dynamic. Flumen river is a Mediterranean river in a semiarid territory with intensive irrigation for cereal, corn, rice and alfalfa production and high concentration of swine farms. Simulated discharge and nitrate concentrations were compared to data collected at the catchment outlet measurements at weekly time step during low flow and daily or sub-daily time step during flood events. Results showed an inverted flow dynamics with respect to the general rainfall pattern as a consequence of the intensive water discharges from irrigation during summer and the peaks loads of nitrates in the river are observed in flood events.

Nitrate concentrations are diluted during flood events and annual nitrate transfer show a low correlation with catchment annual water yield. During the simulation period, nitrate transfer from land area to stream network was mostly associated to lateral discharge.

Keywords

SWAT, Semi-arid catchment, agricultural watershed, nitrates, flood events

Study of Hydrology based on Climate Changes Simulation Using SWAT Model at Jatiluhur Reservoir Catchment Area

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Abstract

Jatiluhur Reservoir Catchment Area is located between $107^0$11'36" - $107^0$32'36" BT and $6^0$29'50" - $6^0$40'45" LS in West Java, Indonesia. The catchment area embraces 380 km^2, which is 8% of the total coverage area in the upstream of Citarum River with the total area of 4500 km^2. The functions of this catchment are essential for meeting the needs of water for agriculture in Karawang and Bekasi area, and drinking water needs for Jakarta area. The purpose of this study was to investigate the impact of climate change on hydrology yield in the catchment. Changes in climate are discovered by several different climate changes scenarios, prepared as input for hydrological model SWAT. Simulation scenarios conducted after the model is calibrated in order to obtain model parameters that are sensitive to the hydrological response. Afterwards models are validated to find out that the model has described the state of the field. The result showed that the values of runoff and water yield are varies based on climate change. Therefore, there is a need to consider the factors of climate change in order to study hydrological process of a watershed.

Keywords

SWAT, hydrology, climate changes scenarios and catchment areas

Using SWAT to predict the Climate change effects on soil runoff and loss in a rainfed small catchment with Mediterranean climate of the NE Spain

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Abstract

Climate change adds an element of uncertainty to the magnitude of erosion processes, which are widespread throughout the Mediterranean areas. The observed trends in temperature and the changes in seasonal precipitation regimes during the second half of the 20th century may enhance the magnitude of the erosion processes. The present research shows the results of the application of SWAT to predict runoff and soil loss in a small basin with vines as main land use. It is located in the Alt Penedès and Anoia region (NE Spain). Input data included detailed soil and land use maps, and daily climate data of the period 2000-2012. The analysis compared the result observed for years with different climatic conditions recorded during the period 2000-2012 and those predicted according to temperature and precipitation for the scenario of 2020 and 2050, according to the trends observed in the area. The model was calibrated and validated using data recorded at different subbasins, using soil water and runoff samples. The SWAT application confirmed the difficulty to predict soil loss in the future, when year to year variability is very high. The model simulates a decrease or soil loos associated with a decrease of runoff, but the most significant result is the effect of the increasing rainfall intensity. An increase of the maximum rainfall intensity in spring and autumn, the main rainy seasons, produced significant soil loss increases, although evaporation increased and less runoff water was available.

Keywords

Climate change, evapotranspiration, runoff, soil losses soil water, vines

Evaluation of Turbidity Water and Eutrophication in Chungju Lake by Future Climate Change Using CE-QUAL-W2 and SWAT

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Abstract

This study is to evaluate the future climate change impact on turbidity water and eutrophication for Chungju Lake in South Korea by using reservoir water quality model (CE-QUAL-W2) coupled with watershed model (SWAT; Soil and Water Assessment Tool). The SWAT evaluates the pollutant loading from the streams of watershed. The SWAT was calibrated for 6 years (2000-2005) and validated for 5 years (2006-2010) using daily streamflow data at three locations and monthly stream water quality data at two locations. The CE-QUAL-W2 model was used to simulate water balance, water temperature, turbidity and algae in reservoir by calibration (2010) and validation (2008). To evaluate the future water environment variation in reservoir, the climate data predicted by MM5 RCM (Regional Climate Model) data of Special Report on Emissions Scenarios (SRES) A1B for three periods (2013-2040, 2041-2070 and 2071-2100) were downscaled by Artificial Neural Networks method. RCM temperature and precipitation outputs and historical records were used to generate pollutant loading from the watershed. By CE-QUAL-W2 model run, the future change in shallow water temperature showed upward tendency by temperature rise, but deep water temperature showed downward tendency. The future yearly average concentration of suspended solids incoming to the lake from the streams showed a decrease from wet year (47.2 mg/L) to dry year (42.2 mg/L). The future predicted residence time above 10 mg/L suspended solids in the lake showed a decrease from wet year (166 days) to dry year (153 days), but the occupying rate of suspended solids showed 6 % increase in the future. The simulation results by climate change showed significant impacts on turbid water and its long lasting. The future predicted Chl-a growth increased in wet and dry year then average year, and peak concentration of Chl-a also occurred in wet and dry year.

Keywords

SWAT, CE-QUAL-W2, Chungju Lake, Climate Change, Turbidity

Acknowledgements

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Application of SWAT in a Brazilian watershed with inconsistent hydrological data

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Abstract

The sediment yield and erosion rates are directly affected by soil conditions, rainfall, land and use pattern changes, management practices and soil preservation. A watershed with an excessive sediment yield could present environmental problems related to siltation processes in its rivers and reservoirs. Deposition of sediments at the bottom of reservoirs and dams may result in volume loss that could also become impairment in water availability for irrigation, human consumption and power generation over the years. Dredging of sediments are expensive solutions that accounts only for the problem symptoms and not for their causes. Therefore assessing the amount of sediment and what causes it are needed to the management and planning of water resources. The present study aims to evaluate the applicability of the SWAT (Soil and Water Assessment Tool) as a study tool for sediment generation estimation for the Lobo reservoir watershed located in the boarder of two brazilian municipalities. Two simulation periods were selected from1977 to 1985 and from 1996 until 2006. After model calibration using SUFI2 for daily and monthly time step the results for the 1977-1985 scenario was worse compared to the 1996-2006 simulation. Even though the first on presents more stream flow gage stations available the simulation could be biased with measurement errors and limitations of the model in the discretization of highly fragmented land-use watersheds. The research aimed to evaluate these outputs, evaluate strengths and weaknesses of the SWAT model to local conditions and suggest further researches.

Keywords

Hydrological modeling, inconsistent data, Lobo reservoir

Soil loss prediction using SWAT in a small ungaged catchment with Mediterranean climate and vines as the main land use

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Abstract

Soil erosion is recognized as the major cause of land degradation in Mediterranean and semiarid environments. The present work shows the results of the application of SWAT (ArcSWAT 2009.93.5) to model soil erosion in an small ungaged catchment (46 ha) located in the Anoia-Penedés region (NE Spain). This area belongs to the Penedés Tertiary Depression, where unconsolidated materials (marls) outcrop. The main agricultural uses are rainfed vines, herbaceous crops (winter barley) and olive trees. The main data sources to run SWAT were the detailed Soil Map of Catalonia, a 5 m resolution DEM and land use / vegetation maps derived from orthophotos taken in 2010. The model was calibrated and validated using field data (soil water content and runoff samples) collected at different subbasins during the period May 2010-May 2012. The model was run for the period 2000-2012, which includes years with different climatic characteristics. Precipitation ranged between 329 mm and 785 mm. Runoff rates ranged between 4 and 20%. Average annual soil losses ranged between 2 and 14 Mg/ha, with clear differences between HRUs depending on soil characteristics and land management. The highest values correspond to areas located near the catchment outlet, where soils were more affected by land levelling operations.

SWAT application to simulate the impact of soil conservation measurements on soil and nutrient losses in a small basin with mechanised vineyards

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Abstract

In recent past decades, new vineyards have been done adapted for labour mechanization. This has facilitated the trafficability of machinery but most soil and water conservation measures, usually existing in old plantations, have been eliminated. When soil is maintained bare to avoid water competition by weeds, important soil and nutrient losses are produced. In this work, the effect of implementing drainage terraces and filter strips in a small catchment, whose main land use is vines, is analysed. The catchment is located in the municipality of Piera, Barcelona province (North-East Spain). Soil and water losses were simulated using the SWAT model for the period 2000-2011, which included years with different rainfall amount and characteristics. The model was calibrated and validated using data collected in the field during the period May 2010- May 2012. The effects of its implementation on soil and water losses were compared with the ones without conservation measures. The annual rainfall recorded during the analysed years ranged between 329.8 and 785 mm with different distribution throughout the year. Runoff rates represented between 4.7 and 21% of total precipitation. Annual soil losses ranged between <1 Mg/ha in the driest year and 14 Mg/ha, in the wettest. Nutrient losses ranged between 0.2 and 2.6 kg N/ha and between 0.1 and 1 kg P/ha, which imply not only a non-point source pollution but economic losses for wine producers. The implementation of drainage terraces produced a reduction of soil losses up to 20%, and the additional effect of the implementation of filter strips reduced soil losses up to 50%.

Predicting the impacts of agricultural management practices on water, sediments and phosphorus loads

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Abstract

Shallow soils of Southern Brazil under tobacco cropping are generally potential for degradation environmental contamination, because they are based on inadequate agricultural operations and excessive fertilizer rates application. Changes in management practices may affect water balance, sediment and nutrient loads of agricultural areas. This paper evaluates by a modeling approach the impact of farming practices on runoff, sediment and phosphorus loads at Arroio Lino watershed, located in Southern Brazil. This watershed is cropped with tobacco mainly under conventional management system and high fertilizer rates application. The Soil and Water Assessment Tool (SWAT) calibrated model was used to generate a 30-year simulation period. Three scenarios of management practices were tested: conventional tillage (CT), minimum tillage (MT) and no-tillage cultivation (NT) with reduction of 50% of fertilizer rate application. Surface flow decreased when decreasing tillage intensity, but the baseflow increased following almost the same order of magnitude. Hence, the percentage deviation in the water yield is only 6% due to change from conventional tillage to no-tillage management practice. The highest decrease in sediment yield was between conventional tillage scenarios and no-tillage scenarios (66%). The phosphorus loads major change (60%) was due to the decrease (-50%) in the fertilizer rate application instead of due to the change in management practices. No-tillage practices did not significantly affect the water yield, but greatly affected sediment and due to reduction of soil erosion. The soluble P losses increased mainly when the fertilised doses increased. In conclusion it can be stated that conventional tillage practices need to be replaced by less intensive tillage practices in order to minimize environmental impacts caused by a particular land use.

Keywords

Soil erosion, Nutrients, Land use scenarios, SWAT model

Testing SWAT under contrasted climate conditions (Province of Québec, Canada)

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Abstract

The most common way of assessing the impact of climate change on water resources combines the use of climate projections and hydrological modelling. However, uncertainties associated to hydrological models, mainly arising from structural and stochastic issues, question our ability to render a satisfactory diagnostic of the impact of climate change on the hydrological regime of rivers.

This study exploits a Differential Split Sample Test procedure (DSST) in order to investigate the temporal transposability of SWAT model under contrasted climate conditions. A calibration/validation procedure was applied on four historical non-continuous periods with actual contrasted climate conditions for the Au Saumon watershed (Nash-Sutcliffe coefficient of the order of 0.7 in calibration), in order to assess model performance under contrasted climate. In this way, DSST results serve as an indicator of the model robustness for climate change applications.

Hydrological projections, based on all four DSST parameter sets, are next compared. The climatic data originated from the Canadian Global Climate Model (CGCM version 3) driven by the SRES A2 scenario and dynamically downscaled by the Canadian Regional Climate Model (CRCM version 4.2.3) over a 45-km grid. Projections are available from 1970 to 2000 (REF) and from 2041 to 2070 (FUT). Five climatic members are available, in order to represent the natural climate variability and frame modelling uncertainties after minor perturbations of the initial conditions. They are here pooled together to increase the representativeness of the REF and FUT time series.

The Au Saumon catchment drains 738 km2 of land. Its altitude ranges between 277 and 1092 m, for a mean annual air temperature of 4.5 °C. Its mean annual precipitation reaches 1284 mm (1975–2003), of which 355mm is snow, leading to a mean annual discharge of 771 mm. Its land use mostly consists of mixed coniferous and deciduous forests and some croplands. Geology corresponds to Ordovician, Silurian, and Devonian sedimentary rocks resulting in limestone, sandstone, and shale type of soils (silt-loam).

Evaluation of SWAT in the context of climate change in a German lowland catchment

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Abstract

Climate change scenarios can be carried out with SWAT to predict the hydrological conditions in a changing climate. These applications are based on a calibration of SWAT to recent data. For accurate climate change scenarios, SWAT has to be able to reproduce the hydrological conditions also for future conditions. To investigate this point, the changes in modeled discharge evoked by different climate change scenarios are compared with the model performance in the evaluation period in a monthly resolution.

For this, SWAT is calibrated for six hydrological stations of the Treene catchment in Northern Germany. Future climate data from the STAR model are then used to run climate change scenarios. Two scenarios are compared with an increase of temperature of 0K and 3K until 2060.

The multi-site calibration provides overall good results for four performance measures. The comparison of monthly averaged flow duration curves for modeled and observed data detects a poor performance for low flows in autumn months. The 3K-scenario runs result in lower discharges in comparison to the 0K-scenario with the largest differences in autumn months. Thus, the months with the worst performance for the evaluation period coincide with those of the largest reduction of discharge in the future period.

Based on this, we see an increasing need to improve the modeling of SWAT for long low flow periods and to increase the ability of SWAT to model climate change scenarios.

Keywords

Hydrological modeling, SWAT, Multi-site model evaluation, Climate change, STAR

Assessing the impacts of climate change on drought in a transitional wet-to-dry Mediterranean region using SWAT: the lower Tagus river basin, Portugal

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Abstract

The Tagus river basin is a transnational watershed, located in a transitional region between humid and semi-arid climate. The lower part of the basin, located in Portugal, has a strategic importance as the source of water supplies for over 4 million people (including Lisbon), while also providing water for irrigation and power generation. The area is also occupied by important forestry and agricultural activities, themselves dependent on climate.

Climate change is expected to increase climatic aridity due to higher temperatures and lower rainfall rates, which in a transitional region are expected to lead to an increased frequency of severe droughts. This could threaten both the climatic carrying capacity for current agricultural and forestry activities, and the available water resources for human use.

This work focused on evaluating the impacts of climate change on drought frequency and severity in the lower Tagus river basin. Climate change scenarios for 2010-2100 for precipitation and temperature under the A2 and B2 greenhouse gas emission scenarios were statistically downscaled for the study area. The Soil and Water Assessment Tool (SWAT) eco-hydrological model was applied to the basin, simulating relevant variables including vegetation water demand and drought stress, soil water availability, irrigation abstraction, streamflow, reservoir storage and groundwater recharge. The results were analyzed in terms of drought occurrence and severity, including:

- meteorological drought, including indices based on precipitation and temperature anomalies;
- vegetation/agricultural drought, including vegetation water stress and irrigation water requirements;
- hydrological drought, including reservoir storage and streamflow rates;
- socio-economic drought, including the capacity to sustain water uses for power generation, irrigation and domestic supplies.

Preliminary results indicate a trend of increasing frequency and severity of droughts at all levels until 2100. However, due to the present ratio of available water resources to demands, the capacity to sustain power generation should be more affected than that for irrigation and domestic supplies.

Climate change impact assessment considering water discharge and nutrients in a mesoscale coastal watershed

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Abstract

A climate change impact study considering water quantity and quality was performed for the drainage basin area of the Ria de Aveiro lagoon in Portugal. The purpose of this study was to assess the water discharge and nutrients input from the catchment to the lagoon under current conditions and climate change. The output of this study is meant to provide useful information to researchers and policy-makers and help in the process of elaborating an integrated strategy for climate adaptation and sustainable development.

The Ria de Aveiro's watershed forms an interface between terrestrial environment and a complex wetland area, which may face serious threats in terms of future regional development and climate warming. The ecohydrological model SWIM (Soil and Water Integrated Model) was used to simulate water and nutrient fluxes in the watershed. SWIM is a semi-distributed model integrating hydrological processes, vegetation growth and nutrient cycles at the river basin scale. The model was calibrated and validated towards hydrology at three different gauges, located within the basin of the major inflow to the lagoon, the river Vouga. Water quality was calibrated at the outlet of the Vouga. Various point sources, mostly in close proximity to the lagoon as well as diffuse pollution from agricultural fields were implemented in SWIM. For climate impact assessment a set of climate scenarios from the ENSEMBLES project was applied for one reference and two future periods.

The results were analyzed towards annual and seasonal changes as well as extreme events (in terms of Q10 and Q90)

Deployment of SWAT-DEG as a Web Infrastructure Utilizing Cloud Computing for Stream Restoration

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Abstract

This study aims to investigate the enhanced accessibility and scalability of the SWAT-DEG model deployed as a cloud service. Frequent monitoring of hydrologic processes and simulation modeling on short (i.e., sub-daily) time steps are essential tools for effective stream rehabilitation and restorationon first and second order streams with drainage areas less than 20 square kilometers. The SWAT-DEG model was developed to assess how changes in climate and land use beget changes in watershed processes such as runoff, sheet and rill erosion, channel geomorphology and sedimentation. Deployment of the model on a user-friendly and scalable web-platform enables a broader population of watershed planners and decision makers to account for urban development, climatic variability and change, and other human activities in the planning process. The environmental Risk Assessment and Management System (eRAMS) was used to facilitate collection and organization of geospatial data, scenario assessment and visualization, and uncertainty analysis. The platform, eRAMS, is operating system independent and deployable on desktop or mobile devices. Application of SWAT-DEG on eRAMS is demonstrated for a rapidly urbanizing watershed in Texas, United States. Implications for application performance and resource requirements (CPU, disk and network) resulting from multi-tier applications of SWAT-DEG as a cloud service are discussed.

Keywords

SWAT, watershed modeling, stream restoration, stream rehabilitation, scalability, accessibility, cloud, eRAMS, SWAT-DEG, channel stability

Integration of dynamic land use change into SWAT using the LUP.dat file and an advanced setup tool

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Abstract

A major issue of many SWAT applications is the impact analysis of land use change dynamics. Most existing research has applied static state land use (change) scenarios on their pre-calibrated case studies. This approach is in conflict with the nature of land use change which rather occurs in a graduate manner as a development result. Although more recent SWAT versions can integrate land use change, the setup of the required LUP.dat file is still inconveniently time consuming. We developed the Land use Change and Slope Adjustment (LUPSA) tool to overcome this obstacle and to enhance the overall SWAT capabilities to integrate land use change dynamics into SWAT. The primary functions of LUPSA are the automated LUP.dat generation that updates hydrologic response units (HRU) monthly or annually, the potential introduction of new HRUs into the model, soil dynamics and HRU slope change consideration and, optional, generates land use change projections. LUPSA therefore improves “classic” SWAT versions assessing the impact of land use dynamics especially for extreme conditions (fast and large change). LUPSA was tested in the Choke Mountain Range (Ethiopia) where land use changes strongly impact on hydrological SWAT outcomes although model uncertainties due to data issues limited the reliability. Another ongoing research on the impact of land use dynamics on the crop yield in European Russia is promising and will additionally be used to present LUPSA. Especially in fast changing (developing) countries the assessment of the time dimension might prove crucial for the valuation of scenarios and furthermore tradeoff considerations.

Development of the SWAT-Integrated Critical Zone Model

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Abstract

The 1D Integrated Critical Zone (1D-ICZ) Model links soil aggregate formation and soil structure to nutrient dynamics and biodiversity. The 1D-ICZ Model integrates models of: a) Flow and transport (Hydrus 1D); b) bioturbation; c) Chemical equilibrium, d) weathering (SAFE); e) C/N/P dynamics and soil structure, CAST; and f) Plant dynamics, PROSUM. The scientific advancement made through the development of the 1D-ICZ model is the rigorous simulation and quantification of the following soil functions:

- C, N and P sequestration in soils, simulated dynamically in relation to soil structure and organic matter protection;
- Biomass production, including effects of exudates and mycorrhizae on nutrient mobilisation and acquisition;
- C stocks in microorganisms, fungi and consumers, as an index of biodiversity;
- Water transformations and filtration.

To upscale the model to simulate catchments, we are using the hydrologic and geochemical model SWAT as aplatform to incorporate the 1D-ICZ Model. Once SWAT has simulated the hydrologic cycle of the basin, water fluxes and storages from the soil and shallow aquifer for each Hydrologic Response Unit (HRU) are routed to the 1D-ICZ to simulate the nutrient and soil structure dynamics of the watershed. The SWAT-ICZ model can quantify the above soil functions at the catchment scale and will be used for Ecosystem Valuation analyses since it links inventory data to indicators representing critical soil functions.

Some modifications to the simulation of irrigation practices in Paddy using SWAT

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Abstract

Rice paddy is the largest staple food consumed by the people around the world next only to maize. However, among the top three cereals, maize, wheat and rice, together which account for 87% of total food grain production, rice consumes the maximum amount of water to produce a unit weight of grain. SWAT is increasingly being used to simulate the sustainability of rice production due to climate change. The irrigation routines in SWAT are primarily developed to simulate agricultural crops that grow in non-flooded condition. As paddy is a hydrophilic crop, it needs flooded condition for its optimal growth and vital metobolic functions. In this study, the irrigation routines in SWAT has been modified to simulate flooded irrigation. For realistically simulating the irrigation, the auto irrigation in SWAT has been modified to simulate the irrigation demand based on the soil water deficit using the depletion factor. Further, conveyance efficiency and application efficiency have been explicitly incorporated to realistically simulate the amount of irrigation returnflow to the aquifer. The modified irrigation routine has been tested in two river basin of India and found to simulate the irrigation in Paddy in a better way.

Evaluation of SWAT's surface runoff estimation using field observed data in the Upper Blue Nile Basin – Ethiopia

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Abstract

This study tests the applicability of the CN method for surface runoff estimation in the Upper Blue Nile Basin of Ethiopia. Field research is conducted in the rainy season of 2011 and 2012 to collect climatic and surface runoff data in three microwatersheds. Comparison is made between collected event surface runoff and simulated surface runoff using the CN method in the Soil and Water Assessment Tool (SWAT). Evaluation of the measured surface runoff and simulated surface runoff without any calibration provided Nash-Sutcliffe efficiency of more than 0.7 in each of the micro-watersheds. This indicates that the model could perform better with model calibration. The appropriateness of the 5-days antecedent rainfall for adjusting the CN for different antecedent runoff conditions was also studied. We found out that there was no direct relationship between antecedent rainfall and runoff generation. Good agreement between the measured surface runoff and simulated surface runoff suggests that linking the retention parameter with the soil water content is an appropriate approach to account the antecedent runoff conditions.

Agricultural drought analysis in the Arrecifes basin (Pampas region, Argentina) using the SWAT model

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Abstract

Agricultural activity is highly vulnerable to weather conditions, and especially to extreme events. In recent years, there have been profound changes in agricultural systems of the Pampas region. The expansion of agriculture to more fragile environments was associated to an increase in the frequency of extreme hydrometeorological events (i.e. droughts and floods), especially in these new productive areas. One of the biggest problems that have been identified is the lack of agreement between public and private agencies, regarding the thousands or millions of hectares affected by these phenomena. The aim of this research was the application of the SWAT model in the Arrecifes Basin (North of the Province of Buenos Aires), in order to assess its aptitude as a tool for detection and characterization of agricultural droughts. To this purpose, the model has been used along with other indicators of agricultural drought. The methodology used consisted of three stages: (i) development of a long term record of the simulated soil moisture (SSM) with SWAT; (ii) analysis of the spatio-temporal variation of the Normalized Difference Vegetation Index (NDVI). It aimed the detection of periods and areas affected by agricultural droughts; and (iii) analysis of the correlation existing between NDVI and SSM. A total period of 20 years was simulated considering both situations involving excess or deficit of soil water, and in which 15 years were considered for calibration and 5 for validation. The results obtained were satisfactory, indicating that with proper parameterization SWAT can be applied to characterize droughts in other similar rural watersheds of the Pampas region.

Keywords

Semidistributed modelling, parameterization, agricultural basin, hydric stress

Assessment of the water availability and water footprint in Argentina for agricultural uses. The AWAA Project

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Abstract

The management of water resources based on a sustainability approach requires knowing the availability of water, its dynamic as well as the amount needed to maintain different processes concerning agriculture production or ecology. The large area of Argentina and its great variability in terms of hydrologic systems and climate, makes it advisable to gather qualitative and quantitative data updated, which is combined with regional scales of simulation. In this regard, the AWAA project will use the SWAT model searching for as general objective to provide a Hydrologic Information System (in terms of availability and productive use) to the whole Argentina aiming to facilitate the tasks of management, planification and water resources conservation. As additional objectives the project have: i) using hydrologic modeling to know the availability and spatio-temporal variability of water resources ; ii) application of the water footprint concept in order to know the pressure on water resources at watershed scale; iii) publishing the results and integration in a public web. The results to be obtained at the end of the project will allow knowing what is the current availability of water resources in Argentina and its productive use. Additionally, the application of water footprint concepts will allow identifying deficit areas and/or areas under high pressure in different regions.

Assessment of point and non-point source pollution in Hindon River Basin using SWAT

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Abstract

Hindon River originates in the lower Himalayas in Saharanpur district of Uttar Pradesh and flows for 260 km until its confluence with the Yamuna. It is a major source of water to highly populated regions of western Uttar Pradesh and the industrial belt around the capital city of Delhi.

The main objective of this study was to assess the performance and applicability of the soil and water assessment tool (SWAT) model for prediction of stream flow and water quality parameters in the Hindon River Basin. The study area was divided into 25 sub-basins. The model has been run for the period of 1972–2006, the period from 1972–1987 has been used for calibration and validation has spanned for the period from 1996-2006. While results obtained for stream flow showed good comparison with observed values using the Nash-Sutcliffe efficiency and percentage bias, the results for water quality parameters showed large deviation from actual values and can be attributed to input data uncertainty in fertilizer application along with industrial wastes in the study area.

Keywords

Hydrology, Runoff, Water quality

Modeling of Suspended Sediment Production Characteristics in Soyang River Basin, a Transboundary Basin located in the Upper North Han River in Korea

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Abstract

In this study, a SWAT model was established for effective turbidity management of the Soyang River watershed and employed to analyze spatiotemporal soil erosion in the watershed which has experienced turbidity problem due to recent concentrated rainfalls. Two stream-flow stations located in the watershed were used to calibrate and validate the model prediction with respect to the observed data from year 2000 to year 2006. The largest monthly SS loading up to 200,000 tons occurred from July to August with the daily SS concentration change following the runoff variance. It was estimated that three sub-watersheds located at utmost upstream including Chohang, Yongsi, and Inbuk areas discharged to Soyang River dam more than 10 tons/ha/yr of suspended sediment. The correlation coefficient (R^2) between the areal percentage of field and annual mean SS load in the 35 sub-watersheds was estimated to be 0.769, implying that agricultural activity at upstream locations should be properly planned in turbidity management. The results of this study including the SWAT model will be utilized for establishment of effective turbid water management by evaluating soil erosion, analyzing soil erosion reduction alternatives, and linking with reservoir models.

Keywords

SWAT, Rainfall-runoff, Suspended Sediment, Soyang River Basin

Acknowledgements

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Modelling the efficiency of nitrate removal by denitrification in the SWAT model

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Abstract

Riparian zones are the interfaces between terrestrial and aquatic ecosystems, which have high efficiency in reducing nitrate originating from upland agricultural fields. The Soil and Water Assessment Tool (SWAT) is a widely used river basin-scale model which has been applied for a variety of hydrologic and environmental problems, however, there are still limited SWAT studies in riparian zone modeling. This paper presents the integration of a conceptual riparian nitrogen model which is based on the Riparian Nitrogen model (RPN) in the SWAT model. The integrated model aims at predicting efficiency in nitrate removal of riparian zones in a river basin-scale. The conceptual riparian nitrogen model RPN which is able to represent nitrate removal by denitrification in riparian zones either as base flow intercepts the root zone or when water is temporarily stored in stream banks during flood events is integrated in SWAT by revising codes. The SWAT model divides each subbasin into two parts: upland area where agriculture fields locate and lowland area which is riparian zone. The SWAT model is modified to allow flow and nitrogen routing from upland area to riparian zone. With the modification, SWAT predicts the nitrogen fluxes from the upland areas and then routes these fluxes towards the riparian zone where the riparian nitrogen model simulates the nitrogen removal in this buffer zone. The integrated model was tested in a hypothetical case study. The preliminary model results show that the riparian zone plays an important role in denitrification when the soil profile in the riparian zone receives a high amount of water from upland areas which results in high groundwater table and allows interactions between groundwater table and the rootzone.

SWATShare – A portal for sharing, publishing and running SWAT model using XSEDE resources

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Abstract

Many hydrologic modelers around the world use SWAT to simulate hydrologic processes, water quality loadings and testing agricultural management scenarios. Once these tasks are complete including publication of results, the models generally are not published or made available to the public for further use and improvement. Although publication or sharing of models is not required for journal publications, sharing of models may open doors for new collaborations, and avoids duplication of efforts if other researchers are interested in simulating a particular watershed for which a model already exists. For researchers, who are interested in sharing models, there are limited avenues to publishing their models to the wider community. Towards filling this gap, a prototype cyberinfrastructure (CI), called SWATShare, is developed for publishing, sharing and running SWAT models in an interactive GIS-enabled web environment. SWATShare is a part of WaterHUB cyberinfrastructure developed at Purdue University to share water related data and models. Users can utilize SWATShare to publish or upload their own models, search and download existing SWAT models developed by others, run simulations including calibration using high performance resources provided by XSEDE, and visualize model outputs. This presentation will discuss the infrastructure behind SWATShare and demonstrate the utility of SWATShare for collaborative research and education.

Keywords

SWATShare; WaterHUB; SWAT; XSEDE; cyberinfrastructure

Combing improved hydrological models with SWAT to predict non-point source pollution in an un-gauged basin

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Abstract

Runoff is one of the most pivotal variables in hydrologic modeling and non-point source pollution (NSP) management. But accurate runoff prediction is quite difficult to achieve in un-gauged basins since no adequate data are available to estimate variables or calibrate a NPS model, especially in high-latitude regions with seasonal freeze-thaw cycles and snowmelt period. This study aimed to predict runoff in a un-gauged basin of a high-latitude river located in Sanjiang Plain, Northeast China with RS-DTVGM (Remote sensing driven Distributed Time Variant Gains Model), And then SWAT was used to simulate the feature of NPS in Sanjiang Plain. The measured runoff at the basin outlet was well simulated by RS-DTVGM with the Nash efficiency coefficients for calibration and validation of the model as 0.70 and 0.56, respectively. The runoff simulation results revealed that runoff prediction using the proposed remote sensing model could achieve satisfactory reliability in un-gauged basins. Finally, the distribution of NSP in that region was discussed in respect of soil erosion, nitrogen and phosphorus loadings. The findings showed that the pattern of distribution in sub-basin was increasing along the river direction in term of spatial perspective. And the NSP was mainly concentrated in April, July and August which was consistent with region's seasonal freeze-thaw cycles and flood period of summer.

Building a meteorological data set as input for the SWAT model in order to simulate the extreme flood event which occured in the municipality of São Luiz do Paraitinga, São Paulo, Brasil, between 31/12/2009-01/01/2010

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Abstract

In recent years, Brazil has figured among the countries with high frequency and intensity of damages caused by extreme events of floods and droughts. The worldwide increase in disasters occurrence has been attributed both to a change in environmental conditions (increase in frequency and intensity of extreme events) as to an increase in the overall population, especially in places considered as "risk areas". A high number of floods has been reported for the southern and southeastern parts of the country in recent years. The Brazilian Atlas of Natural Disasters - volume São Paulo, identified the largest number of flash floods in the last two decades in this state, which mainly occur during the months of December, January and February. This article presents the partial results of a research which aims to investigate the causes and the short, medium and long-term consequences of an extreme flood event occurred in the municipality of São Luiz do Paraitinga, São Paulo, Brazil, between Dec, 31 2009/Jan, 01 2010. In order to identify the causes of this event (i.e., meteorological or hydrological extreme), we are going to use the SWAT model. This article presents the steps followed in order to get the meteorological data set, as an initial input data for the model. Due to the lack of observational weather data set with extensive time series for the study area, we conducted a joint assessment of the various data sources available, such as: *in situ* stations, satellite data, reanalysis products and interpolation. The steps followed to build the meteorological data set are presented here.

Keywords

Natural disasters; SWAT model, flash flood event, meteorological data set

Development of a soil database for applying SWAT model in a catchment of the Brazilian Savanna

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Abstract

Knowledge about physical and hydraulic characteristics of soils is fundamental for the proper application of physically-based hydrological models with distributed parameters, such as the SWAT model (Soil and Water Assessment Tool). In Brazil, since 1999 the number of SWAT users and applications are increasing in an accelerated way. In the case of the Brazilian Savanna region (Cerrado biome), the first applications are very recent and, in general, generic soil database or pedotransfer functions, as well as the default data developed for other soil types and regions, were used. This study aimed to present a reference soil database for applying SWAT in catchments of the Brazilian Savanna. Based on soil samples and analyses, performed at least in triplicate, the following soil characteristics were measured: bulk density, soil-water retention curve, hydraulic conductivity, organic matter, and soil texture. Using soil data collected in 66 sites and three depths, most of them in the Upper Jardim Experimental River Basin, Federal District, Brazil, a conceptual model for introducing this data in SWAT was proposed, as well as a summary table showing the average and range for each of the soil parameters considered by the model. Seven representative soils commonly found in the Cerrado biome were covered by this study. Considering the soil data used in previous applications of the SWAT model in catchments of the region, the results of this study may represent a step forward to obtain more realistic hydrological models, with better physical basis.

Keywords

Hydrological modeling, soil database, model calibration, Brazil

Comparison of Green-Ampt and Curve Number Infiltration Methods in a single-gauged Brazilian watershed

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Abstract

The current SWAT model presents two methods of estimating the runoff: the SCS curve number procedure and the Green & Ampt infiltration method. CN is a model for estimation of runoff that was developed by the USDA in the 1950s.This method is quite simple to use, is a function of the precipitation, soil´s permeability, land use and initial water content of the soil. The G&A Method assumes a homogenous soil profile with initial uniform moisture distributed in the profile. As the water infiltrates into de the soil, the model assumes the soil above the wetting front as completely saturated. Most of the SWAT publications use the CN procedure and only few applications using the G&A are available for tropical weather. A major limitation of the curve number method is that rainfall intensity and duration are not considered. The Green-Ampt method is a time-based model and can simulate impacts of rainfall intensity and duration and infiltration processes. The rainfall is more severe in the tropics; the amount of total rain that fall is much greater than in the temperate zone these events have greater influence and impact on erosion processes on the watershed in this region. The research aims to evaluate the differences between the two approaches on a tropical watershed. The study area is the Lobo reservoir located in the boarder of two municipalities (Itirapina and Brotas). This reservoir is currently used for power generation and tourist attraction. The simulation period is from 2002 to 2011. After model calibration using SUFI2 for daily, monthly and yearly time step, the hydrological output data obtained. The daily simulation results for the G&A method showed improvement compared to the CN methdod, but regardless to the high sensitivity of the model to the runoff processes, as the time step increased to monthly and yearly there was little difference between the two approaches.

Keywords

Runoff, Green-Ampt Method, SCS Curve Number, Hydrological Modelling

From Rubber to Oil Palm: Simulating the Consequence of Large-Scale Agricultural Conversion on Leaf Area Index and Eventual River Flows

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Abstract

Interception by vegetations is an important hydrologic process which influences the rate and spatial distribution of water flux available for other processes such as evaporation and runoff. The degree of the interception has a bearing on the time of runoff concentration which could eventually determine the magnitude of peak stream flow. Interception rate is very much influenced by the characteristics and amount of plant canopies that are usually expressed as a dimensionless quantity known as Leaf Area Index or LAI, where higher LAI would normally lead to greater interception. Thus, large-scale conversion of agricultural land use within a watershed, for example from rubber to oil palm plantation, could very well affect the local hydrologic cycle and eventually the flow pattern of a river. This paper discusses a study that employs SWAT version 2009.10.1 to simulate the impact of large scale LAI changes on the flooding frequency and magnitude of Muar River in Johor, Malaysia. LAI data within the 4700-km^2 watershed for the years 2002, 2006 and 2008 were downloaded from The National Aeronautics and Space Administration (NASA)'s website and interesected with the land uses of the watershed for the same years. As the composition of the watershed's two major agricultural vegetations (rubber and oil palm) changed over those years in favor of oil palms, the overall mean value of LAI decreased from 4.12 in 2002 to 2.5 in 2008. This reduction in overall LAI resulted in the expected increase in peak stream flows which was successfully simulated by SWAT. This helps explain the more frequent flooding events within the watershed even under less severe rainfalls. Thus, changes in land use/land cover need to be understood also in terms of LAI if we are to understand the hydrological impact of the changes.

Keywords

Watershed, Leaf Area Index (LAI), oil palm, rubber, SWAT, runoff, flooding.

Modeling flow and pesticide transport through surface water diversions in the California Central Valley

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Abstract

The watershed of the California Bay-Delta encompasses a large, complex network of engineered structures for flood control, irrigation, and drinking water; often transporting surface water to destinations hundreds of miles away. These diversions are substantial in magnitude, may be highly variable in time, and lack monthly or seasonal patterns. Accurately modeling surface water diversions including the simultaneous transport of nutrients and pesticide mass is critical to understand the fate and transport of such chemicals and to better predict their concentrations throughout the watershed. Currently, the SWAT model transfer scheme permits a constant daily transfer amount or a constant fraction of flow, and does not properly account for the transfer of nutrient and chemical mass. Our work enhances the existing transfer operation by allowing daily or monthly time series of diverted flow rates to represent the appropriate temporal variability in transfers. Diverted pesticide mass is computed based on the ratio of diversion to overall flow rates. We use this modified scheme to model 9 daily-time-series and 24 monthly-time-series of flow and pesticide mass transfers throughout the Central Valley using California Department of Water Resources and U.S. Geological Survey data. This includes flood water spillage over weirs along the Sacramento River, and Sacramento and San Joaquin River water movement to federal and state pumping facilities that export up to half the total Delta inflow. Comparison with USGS gage data shows that the modified transfer scheme improves simulation of surface flow and mass concentrations in nearly every major reach in the watershed.

Detailed spatial analysis of the plausibility of surface runoff and sediment yields at HRU level in a mountainous watershed in China

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Abstract

The Three Gorges Region in China is characterized by severe soil erosion, which leads to a degradation of soils and receiving surface waters and indicates a need for sustainable watershed management including the adoption of BMPs (Best Management Practices) to reduce soil erosion. For an effective targeting of BMPs the identification of CSAs (Critical Source Areas) within watersheds is crucial. Watershed models like SWAT (Soil and Water Assessment Tool) are valuable tools that facilitate the identification of CSAs in large watersheds and the assessment of the effectiveness of BMPs without time-consuming and costly field experiments.

In this study, SWAT was applied to the Xiangxi Catchment in the Three Gorges Region. Surface runoff and sediment yields were analyzed at HRU (Hydrologic Response Unit) level. This allows for a more precise targeting of BMPs than analysis at subbasin level. Additionally, it provides the opportunity to validate simulated amounts of surface runoff and sediment yield by checking the plausibility of their spatial variation within the watershed based on expert knowledge.

Results of this study indicate that satisfactory model performance at the gauge does not guarantee plausible results at HRU level. Both surface runoff and sediment yields display reasonable variation with land use and soil types, but not with slope. However, a plausible variation of processes as a function of slope is considered very important in mountainous watersheds like the Xiangxi Catchment. With regard to surface runoff, inconsistencies can mostly be attributed to minor simplifications in SWAT algorithms computing surface runoff and to a strong indirect impact of lateral flow on surface runoff. Plausibility of surface runoff was increased in this study by modifying and recalibrating selected SWAT algorithms and parameters. However, the effects of these modifications on sediment yield are marginal. This can be explained by the non-linear relationship between sediment yield and HRU area in the Modified Universal Soil Loss Equation used by SWAT for calculating sediment yield, which allows the HRU area to exert a stronger influence on estimated sediment yields than the remaining factors of the equation.

This study demonstrates that a detailed analysis of model output at HRU level during model calibration is highly recommendable. It is of particular importance when SWAT is used as a tool to identify CSAs for targeting BMPs.

On the auto-calibration of watershed models: multisite many-objective measures of information

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Abstract

Watershed models play a central role in successful implementation of watershed management programs by providing the means to assess the relative contribution of different sources to water quality impairment. Therefore, it is imperative to evaluate the performance validity of watershed models according to past observations of water and contaminants fluxes at multiple locations on the stream network. The primary goal of this study is to present a framework for multisite many-objective calibration of watershed models that can incorporate user-specified priorities considered for model application. A case study is presented to demonstrate the application of the proposed computational framework for calibration of the Soil and Water Assessment Tool (SWAT) for hydrologic and water quality modeling using four single- and multi-objective optimization methods in the Eagle Creek Watershed, Indiana, USA. This study reveals that aggregation of streamflow and nitrate information measured at multiple locations within the watershed into a single measure results in faster convergence to a solution with a lower overall objective function value. However, the solution from the adaptive Markov chain Monte Carlo method of DREAM is the only single objective approach that satisfies the conditions characterizing the system behavior. This study also highlights the use of multi-objective approaches for proper calibration of watershed models used in pollutant source identification and watershed management. A new autocalibration tool is also demonstrated that provides a user-friendly environment for calibration of SWAT models using several optimization methods and a flexible definition of objective functions.

A comparison study of multi-gage and single-gage calibration of the SWAT model for runoff simulation in Qingjiang river basin

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Abstract

As a typical distributed hydrologic model, the SWAT model was often used for runoff simulation in river basins. For applying the model, parameters have to be calibrated beforehand. Traditional way of calibrating the model was performed based on the observed flow data at a single gage at the outlet of the basin. However, there are occasions that multi-gage calibration of the SWAT model are necessary when, (1) flow regimes at multi-site are interesting for, e.g., flood defense purposes; and (2) the spatial variations of hydrological characteristics at different sites of the basin are interesting to be discovered.

Therefore, a comparison study was carried out in this paper to reveal the differences between the multi-gage and single-gage calibration of the SWAT model for runoff simulation in Qingjiang river basin in China.

The whole basin was divided into five sub-basins by using the 5 flow gages as the outlets of the sub-basins. Daily flow data with a time span of 3-year (1993-1995) were used use for this study. Where, data from 1994 were used for calibration and 1995 for validation.

Different numbers (from 1 to up to 5) of flow gages were used to perform multi-gage calibrations, to compare the simulation accuracies against single-gage (at the outlet of the whole basin) calibration. The results revealed that, the flow simulation accuracies at the outlet of the whole basin are similar between all multi-gage (from 2to 5 gages) calibration scenarios and single-gage calibration. But the flow simulation accuracies at the sub-basin outlets other than the outlet at the whole basin were improved by a factor of 3-20%. A detailed check of the parameters of the sub-basins indicating that parameters in the sub-basins obtained by using multi-gage calibration can better depict the local hydrologic characteristics of the sub-basins, which should be the reason of these accuracy improvements.

Keywords

SWAT model; Single-gage calibration; Multi-gage calibration

Coupling SWAT and MODSIM for Basin-Scale Water Resources Management: Example Karkheh River Basin in Iran

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Abstract

Population growth and increasing water demand in different sectors, in combination with spatial and temporal variability of rainfall and uncertainties caused by climate change impact underscore the need for sound interdisciplinary management of water allocation. A coupled system, consisting of hydrological and water allocation models is highly desirable for optimum water resources management. The hydrological model Soil and Water Assessment Tool (SWAT) was coupled to MODSIM water allocation model. SWAT is used to simulate water availability while MODSIM is used to optimize water supplies to different non-consumptive and consumptive water users. The coupled system was applied to the internationally recognized benchmark basin Karkheh located in southwest Iran. Optimum water allocation was evaluated subject to an objective function that minimized the cost of water transfer. Three cropping patterns constraining cropping areas of cereal production to 50% (S1, historic), 17% (S2), and 83% (S3) of total agricultural areas were analyzed subject to three climate scenarios (A1B, A2, and B1) of the Canadian Global Coupled Model (CGCM 3.1 version T63). Analyses of the three cropping patterns in five economically important regions of the Basin (Dashte Abbas, Dolsagh, Arayez, Hamidiyeh, Azadegan) showed that the highest impact on the economic return occurred in Dashte Abbas and Dolsagh. It was found that for all climate scenarios the cropping pattern S2 generated the highest economic return.

Temporal analysis of parameter sensitivity and model performance to improve the representation of hydrological processes in SWAT for a German lowland catchment

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Abstract

A model evaluation for the whole discharge time series leads to an overall assessment of the model performance. However, temporal differences in the model performance, i.e. for different parts of hydrograph, were not considered. Furthermore, the model components which are the origin of the poor performance cannot be detected with classical model evaluation approaches.

In this study, the temporal dynamics of parameter sensitivity and model performance were investigated for the Treene lowland catchment in Northern Germany. A temporal sensitivity analysis was carried out to determine variations of dominant model parameters. Periods with poor performance were detected with an analysis of temporal variations in the values of different performance measures. By relating the periods of poor model performance to the dominant parameters in these phases, the origin of these model errors can be identified.

The temporal analysis of the parameter sensitivity illustrates that the sensitivity varies within the discharge time series. Three groundwater parameters (GW_DELAY, ALPHA_BF, RCHRG_DP) dominate in peak and recession phases while the evaporation parameter ESCO is dominant in baseflow and resaturation phases. By temporally analyzing the model performance, three clusters which are characterized by different values of six performance measures were separated and related to different phases of hydrograph. The worst performance was found for the baseflow cluster.

Thus, the groundwater module was determined as the part of SWAT with the highest potential for model improvements. In this way, the proposed temporal diagnostic analyses improve the understanding of SWAT.

Keywords

Temporal diagnostic analysis, sensitivity analysis, model performance

Groundwater as the dominant control process to model recession and baseflow phases in lowland catchments

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Abstract

The groundwater contribution to river discharge in North German lowlands is a key factor for a reasonable representation of the water balance. In common with many lowlands, there is a strong interaction between near-surface groundwater and rivers. The winter season is characterized by high discharge conditions whereas the end-summer tends to distinctive low flow periods. Several studies revealed that the SWAT model may cause poor model performance for low flow periods, which are mainly controlled by groundwater. The reason could be the complexity of the processes in groundwater-dominated lowlands, which cannot be fully reproduced with one single contributing groundwater aquifer. Considering the non-linearity of the baseflow process, it is favourable to adapt the groundwater module of the SWAT model. In our investigations we divided the shallow aquifer to simulate a fast and a slow flow component of the groundwater. The deep aquifer without connection to the stream is still included in SWAT to account for water, which percolates into deep geologic formations. The new SWAT version leads to good prediction of the overall discharge especially for the recession limbs and the following low flow periods. The enhanced performance is reflected in the signature measures for the mid segment (PBIAS: 12:8% vs. 20:8%) and the low segment (PBIAS: -27:4% vs. -54:7%) of the flow duration curve.

Keywords

Low flow, recession, groundwater, lowland, baseflow

Adapting SWAT for the Modeling of Pesticide Transport for a Tile-drained River Basin

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Abstract

Artificial drainage systems are responsible for the transport of large amounts of pesticides into surface water. The resulting contamination is widely documented as one of the most important stressors for aquatic ecosystem degradation. In this study, SWAT2005 (Soil and Water Assessment Tool) was applied on a heavily tile-drained agricultural basin - the Odense river basin with area of 612 km^2 to simulate pesticide transport into surface water. The model was modified to account for pesticide transport via tile drains. Simulations were carried out for three pesticides: bentazone, (4-chloro-2-methylphenoxy) acetic acid (MCPA) and pendimethalin. The objectives of the study are to evaluate the model performance with/without model modifications, to partially quantify pesticide transport into streams and to identify the main pathways for pesticide transport.

Results revealed that in SWAT, the mass balance of pesticides was not fully closed. Despite this inadequacy, the modified SWAT model enabled the prediction of pesticide loss through tile flow during wet season and therefore gave more realistic results than the original model. The modified SWAT simulates four pesticide transport pathways. The dominating transport pathway was identified as lateral flow, tile flow and surface runoff (in solution) for bentazone, MCPA and pendimethalin, respectively. For bentazone and MCPA, the modified model acceptably predicted the total loads and the maximum instream concentrations. But the prediction for pendimethalin tended to give an overestimation of the maximum instream concentrations. Further development to the SWAT pesticide module is therefore required to better represent pesticide mass balance and its transport into surface water.

Keywords

Pesticide modeling, SWAT, transport pathways, tile flow

An integrated modelling of interactions between human decision-making and hydrological processes: The MAELIA multi-agent platform

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Abstract

The MAELIA project (Multi-Agent for EnvironmentaL norms Impact Assessment) develops a simulation platform for the assessment of the socio-environmental effects of norms of governance and management of water resources given the social and environmental changes. It focuses on the modelling of low-water management, which is the most strategic water issue in the Adour-Garonne basin (South-West France). To address the direct/indirect or expected/unexpected effects of the investigated endogen and hexogen factors, the platform represents and simulates hydrological, agricultural and normative processes and their interactions. To represent the hydrological processes (the soil phase and the routing phase of the water cycle) the SWAT rules have been analysed and re-implemented into the MAELIA software developed based on the GAMA agent-based modelling and simulation platform(see Hong et al., 2013, this conference). The originality of the platform comes from a multi-agent approach where a large number of software agents simulate the spatialized and dynamic behaviors of actors playing a role in water management and uses: agricultural, domestic and industrial withdrawals, management of water stored in dams, regulations of water uses.

In this paper we focus on the original conceptual and software frameworks of MAELIA regarding the representation and simulation of interactions between the human decision-making processesand the ecological processes at a high spatial and temporal resolutions. We sketch how human decision-making processes are represented and how we manage interactions of different processes with their own spatial and temporal resolutions (field, farm, HRU, water sub-basin, regulation zone, dam watershed…). We highlight our modeling approach that simulates reciprocal and continuous feedback between human activities and hydrological processes to the difference of approaches based on the sequentially use of an agent-based model, to simulate human behaviors, and then of SWAT to simulate effect of these activities on the water cycles. Finally we discuss the challenge currently faced, related to calibration and evaluation issues and simulation of scenarios of the socio-hydrosystem evolutions over decades.

Keywords

Agent-based model, social-ecological system, human decision-making process, hydrological process, water management

Application of the PCPF-1@SWAT model in the Sakura River basin in Japan and Colusa Drain basin in California, USA

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Abstract

In Europe, rice is cultivated over 410,000 ha which are mainly located in the Mediterranean countries. Since rice is usually grown under flooded condition, the potential for contamination of water bodies is high. As a result, pesticides were frequently detected in the surface and groundwater systems adjacent to rice fields. The fate and transport of pesticide applied to rice paddy fields in Europe was investigated using models such as RICEWQ, PCPF-1, PADDY, and SWAGW. However, these models can only be applied to watersheds where rice is exclusively cultivated.

To address this problem, the PCPF-1@SWAT model was developed by coupling the field scale rice pesticide fate and transport model, PCPF-1, and the watershed multi-purpose agricultural model, SWAT. The PCPF-1@SWAT was used in the Sakura River basin, Japan to predict mefenacet concentrations, and in the Colusa Drain basin, USA for predicting molinate and thiobencarb concentrations.

The hydrology of the Sakura River watershed was mainly naturally driven and well simulated by the PCPF-1@SWAT model, whereas the simulation of hydrology in the Colusa Drain basin watershed presented a great challenge due to anthropogenic water transfer within and between sub-watersheds. Simulated pesticide concentrations in paddy fields for both regions were similar to the concentrations reported in literature. In both watersheds, pesticide concentrations in the main stream were accurately simulated however they were very sensitive to factors affecting the paddy fields water balance. Consequently the water management and paddy fields conditions are critical inputs for realistic predictions of rice pesticide fate and transport at watershed scale.

Application of a SWAT model to assess the impacts of diffuse pollution from vineyards in north-central Portugal

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Abstract

An important shortcoming of the Water Framework Directive is its failure to explicitly account for the risks posed by climate change on the chemical and ecological status of aquatic systems. The relationship between climate change and diffuse agricultural pollution, in particular, is a complex issue and is still poorly investigated. The VITAQUA project has been designed to study the impacts of climate changes on the hydrological processes, chemical pollution, and ecological status of aquatic systems located nearby intensive agricultural areas. In order to achieve this goal, a SWAT model will be applied to the Cértima catchment area (538 km^2), located within an important Portuguese winegrowing region. As a first approach, SWAT will be applied to the São Lourenço sub-catchment (6.2 km^2), an area occupied by c.a. 40% of vineyards, which was instrumented with a hydrometric station and runoff and erosion plots on October 2011. This strategy will allow an evaluation of model reliability to simulate the input of agrochemicals (nutrients and pesticides) to aquatic systems in intensive vineyard areas, before upscaling it to the Cértima catchment. The present work, in particular, will focus on model implementation and parameterization for the São Lourenço experimental catchment. SWAT parameters will be estimated from the available soil, land use and meteorological data, as well as on the existing information on vine ecophysiology and regional vineyard management practices, including fertilization and pesticide application procedures. After calibration and validation, model results will be combined with microcosm bioassays that were designed to study the effects of temperature and anthropogenic stressors on ecosystem functioning. Such an integrated approach will provide a more comprehensive overview of the effects of climate changes on the quality status of freshwater systems.

Modeling of pesticide fate in a Luxembourgish catchment with the Soil and Water Assessment Tool (SWAT) - combining modeling and monitoring

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Abstract

We applied the Soil and Water Assessment Tool to the Wark watershed in Luxembourg to assess the export of Terbuthylazine from agricultural fields. The watershed has an area of around 85km^2, with 19% coverage of arable land. According to the official agricultural statistics, winter cereals (mainly wheat and barley) as well as corn and oilseed rape are the main cultivated crops in the watershed. The Wark watershed features shallow soils mainly over bedrock, resulting in high rates of lateral subsurface flow and rapid streamflow response to rainstorm events.

In the first step of the study we used distributed passive sampling (POCIS) and an auto sampler at the watershed outlet to monitor and characterize the dynamics and quantity of pesticide export from agricultural fields in the watershed. The results of these measurements were used to validate the model output. The results of the SWAT simulations are used to identify hot spots of pesticide exports in the watershed. Additionally an uncertainty analysis was conducted to assess the importance of accurate input data (e.g. the amount of known pesticide and application dates) for the simulation of pesticide fate using the SWAT model. We will present the results of this study and discuss the usefulness of this combined monitoring and modelling approach for predicting chemical loads from agricultural fields.

Developing new bacteria subroutines in the SWAT model

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Abstract

Fecal bacteria observations from four different sites in Korea and the US show a seasonal variability, showing a significant relationship with temperature; fecal bacteria concentrations are relatively higher in summer and lower in winder season in the observations, including Stillwater river (STR, Massachusetts), Jumping Run Creek (JRC, North Carolina), Little Cove Creek (LCC, Pennsylvania) and Komacwon Creek (KMC, South Korea). We also found that fecal concentration does not have a significant relationship with precipitation. It is counter-intuitive that surface runoff and resuspension driven by precipitation could result in high fecal concentration. This implies that temperature is the one of key parameters on the seasonal variability of re-growth or die-off of bacteria in soils and in-streams. Existing watershed models, however, have a limitation of simulating this seasonal variability of fecal bacteria. Soil and in-stream bacterial modules of Soil and Water Assessment Tool (SWAT) model are oversimplified to simulate the seasonal variability of bacterial die-off and re-growth . Here, this study develops new bacteria subroutine of SWAT to improve its prediction accuracy and test the modules with observations from four different sites. It includes soil and in-stream bacteria modules of SWAT which is enhanced by adding critical temperature parameter to simulate die-off and re-growth in soil and in-stream modules. Here, if air temperature is greater than critical temperature, re-growth is dominant. Otherwise, die-off is dominant. We compares observed and predicted fecal coliform bacteria concentrations at four different sites in Korea and the US. We found that the bacterial modules developed by this study are capable of simulating the seasonal variability of bacteria, showing satisfactory accuracies.

Assessment of climate change impacts on diffuse nutrient and pesticide fluxes at the watershed scale

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Abstract

This study aims to assess the potential impacts of the changing climate on pollutant fluxes including sediment, phosphorus, nitrogen, and atrazine at the watershed scale over the 21st century. Specific objectives are (i) to understand changes in climatic conditions under a comprehensive set of 112 climate projections consistent with Intergovernmental Panel on Climate Change Special Report on Emissions Scenarios (IPCC-SRES) emission pathways and models; (ii) to fully enumerate and synthesize hydrologic and water quality responses to projected climate scenarios; and (iii) to investigate changes in dissolved and particulate water quality constituents. These objectives are investigated in a predominantly agricultural watershed in the Midwestern United States. The hydrologic model Soil and Water Assessment Tool (SWAT) is utilized to represent processes governing hydrology and water quality within the watershed. Predicted changes in hydroclimatic, nutrient, and pesticide fluxes under the 112 distinct simulations are analyzed by emission pathway ensemble and characterized over early-, mid-, and late-century assessment periods. Clear warming trends are apparent for temperature, while increases in precipitation are insignificant. Stream discharge, sediment yield, and total nutrient yields do not differ significantly between assessment periods, although atrazine yields are predicted to be slightly greater by late-century. However, the proportion of dissolved to total nutrients increases, with nitrate and soluble phosphorus yields increasing significantly between early- and late-century. The projected increase of bioavailable forms of nutrients highlights the importance of long-term impacts of climate change on water quality, and has implications for management of reservoirs and drinking water supplies.

Best Management Practices in Agricultural area using a Multi-objective Decision Support System to Reduce Total Phosphorus Loading

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Abstract

Agricultural activities have mainly contributed to increase of total phosphorus (TP) loads by non-point source in a receiving waterbody. Especially in Yeongsan River, tillage practices and fertilizer application have been recognized as a major factor of eutrophication. The objective of this study is to suggest optimal BMPs to efficiently reduce TP loads by applying structural and non-structural BMPs to both rice and soybean area. However, BMPs are difficult to select type and placement because of diversity of pollutants reduction rate and implementation costs of BMPs. Therefore, Soil and water assessment tool (SWAT) and Multi-objective decision support system (MODSS) used to solve difficulties of selection and placement of BMPs. The SWAT model was used to calibrate and validate for daily flow discharge, monthly sediment load and monthly TP loads using monitoring data from 2000 to 2010. MODSS based on evolutionary biology such as selection, crossover, mutation, and reproduction was used to optimize the objective functions which are associated with TP loads and cost for implementing BMPs. As a result, this study identified that contour cropping was the most optimized BMPs in rice area and conservation tillage and riparian buffer were the most optimized BMPs in soybean area. And, the reduction rate of TP loads by applying optimized BMPs in Yeongsan-river watershed resulted in 40 % with cost for implementation as $ 0.6 million dollars. This study may be helpful for improving the water quality of Yeongsan River by applying the optimized BMPs in rice and soybean area of Yeongsan-river watershed.

Coupling SWAT and MOHID WATER coastal numerical model

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Abstract

This presentation will show two applications where SWAT was coupled with Mohid Water. One application in Umbeluzi watershed in Mozambique. This application shows the flooded area estimated with Mohid Water model using SWAT flows has input. Another application shows SWAT flow estimated under climate changes scenario and its impact on Coastal Lagoon. The Umbeluzi River basin has a total area of 5458 km2, which 40% are located in Mozambique, 58% in Swaziland and 2% in South Africa. In terms of topography, about 20% of the area is above 500 meters, peaking at 1800 meters. The SWAT model was used to simulate the present catchment hydrology. Available GIS maps for topography, land use from EO data (Earth Observation data) adapt to the SWAT classification, and soils of the study area were used. The MOHID water model was used to assess the implication of the high flow period in 2000 in water level in the river associated with the effect of the tide. Seventeen flow stations located at Umbeluzi river were used to evaluate SWAT model results. Very few data on precipitation were available. MOHID WATER was validated with point measurements of tide and with profiles of Temperature and salinity. Vouga watershed is located in central Portugal, extends across an area of approximately 3400 km2, and discharges into the Ria de Aveiro, a tidal coastal shallow lagoon. The SWAT model was used to simulate the present catchment hydrology and in a future climate change scenario. The MOHID water model was used to assess the implication of the discharge modification on the Ria de Aveiro hydrodynamics and salinity distributions. The SWAT model was calibrated and validated using long historical flow records in two gauge stations. Mohid Water results were validated using velocity and salinity measurements available for the Ria de Aveiro. Climate change scenarios were obtained using the ECHAM5 coupled atmosphere-ocean model. This model provided precipitation changes expected which were used to modify the SWAT input. Wavelet analysis was applied to SWAT output discharges in order to assess of oscillation periods modification. Results show that low-frequency oscillations in flow have a tendency to increase and Mohid Water shows that an overall increase in salinity must be expected.

Modeling the Impacts of Climate Change on the hydrology of the Devils Lake Basin of North Dakota

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Abstract

Devils Lake (DL) of North Dakota is a terminal lake of roughly 9,500 km^2 closed drainage basin, the Devils Lake Basin. Since 1990, DL water level rose nearly 10 m, with over 400% increase in surface area (from 185 km^2 to 772 km^2) and 600% increase in water volume (from 0.74 km^3 to 4.4 km^3) costing over one billion dollar in mitigation. In the absence of natural outlets, DL keeps on growing in size inundating more lands until it reaches the threshold elevation of 444.7 m, over which it overflows into the nearby Sheyenne River causing downstream water quality issues. Use of artificial outlets to divert DL water to the Sheyenne River has already been challenged in court. Therefore, DL water level fluctuation is critical to make flood management policy. In this study, we use the Soil and Water Assessment Tool (SWAT) to (1) model the DL basin hydrology, and (2) estimate future water levels of DL under the Intergovernmental Panel on Climate Change SRES scenarios for 2020s (2011 to 2040). The constructed hydrological model of the DL is calibrated and validated for 20 years (1991 to 2010) using daily streamflow records. Both R^2 and $E_{NS} > 0.6$ for calibration and validation period demonstrate the excellent performance of the model. Future climate conditions in the region are estimated by combining historical weather data (1981-2010), General Circulation Model projections from the IPCC data center and NARCCAP project, and stochastic downscaling methodology (LARS-WG). Our results of the experimental model runs indicate that DL has approximately 7% chance of overflowing into the Sheyenne River by 2040.

Effects of different spatial and temporal weather data resolutions on streamflow modeling of a semi-arid basin, Northeast Brazil

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Abstract

One major difficulty in the application of distributed hydrological models is the availability of data with sufficient quantity and quality to perform an adequate evaluation of a watershed and to capture its dynamics. This paper uses SWAT to analyze the hydrologic responses to different sources, spatial and temporal resolutions of weather inputs for the semi-arid Jaguaribe watershed (73,000 km^2) in northeastern Brazil. Four different simulations were conducted, based on four groups of weather and precipitation inputs: Group 1- SWAT Weather Generator based on monthly data from four airport weather stations and daily data based on 124 local rain gauges; Group 2- daily local data from 14 weather stations and 124 precipitation gauges; Group 3- Daily values from a global coupled forecast model (NOAA's Climate Forecast System Reanalysis - CFSR); and Group 4- CFSR data with 124 local precipitation gauges. The average annual precipitation from CFSR is 20% higher than the precipitation from the local gauges with SWAT's weather generator for the missing data. All of the simulations overestimated the flows, the Group 1 simulation performed overall better (providing the best values of PBIAS and NSE), followed by the Group 4's simulation, suggesting that using CFSR data for weather parameters other than precipitation, coupled with precipitation data from local rain gauges, can provide reasonable hydrologic responses. Group 2 generally performed worse than Groups 1 and 4, due to the uncertainty related to daily precipitation data and the high percentage of missing data, the Group 3 simulation overestimated the flows the most.

Keywords

Hydrological analyses of different weather inputs, Global Weather data base, SWAT model, Brazil, semi-arid.

Using SWAT to understand the eco-hydrological response to droughts of a dry Mediterranean agro-forested catchment, southern Portugal

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Abstract

Climate change is expected to increase aridity in the Mediterranean rim of Europe, leading to concerns on consequences for water resources availability in a region already under water stress. In consequence, there is an interest in understanding how streamflow availability has responded to past droughts, and how this might reflect future water availability conditions. To study this issue, the SWAT model is being applied to Guadalupe, an agro-forested catchment (446 ha) located close to the city of Évora, with a Mediterranean inland climate. The landcover is a mix of dispersed cork oak forests (“montado”), annual crops, and agroforesty regions where the cork oaks are associated with crops or pasture; this landcover is representative of the dry regions of southern Portugal. The catchment is representative of the streamflow sources for a network of reservoirs in the Évora region which provide water for irrigation and hydroelectric power generation.

The catchment has been instrumented since 2011 with a hydrometric station and a soil moisture measurement station, and the already collected data includes the winter drought in 2011/2012. There are also two eddy covariance flux towers at a distance of around six kilometers from the study catchment (Mitra and Tojal), where actual evapotranspiration was monitored between 1999 and 2008, including the drought of 2004/2005. Water balance in SWAT is currently being calibrated with this dataset; future work will include the upscaling of the model for regional catchments, and its application to evaluate the impacts of climate change scenarios.

This work will present the dataset, modeling process and preliminary results.

Assessing hydrological processes performance of SWAT on a small forested watershed

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Abstract

The Soil and Water Assessment Tool (SWAT) was previously applied in Aixola watershed (Basque Country, Northern Spain) in order to explore the potential impacts of climate change on runoff and suspended sediment yield. Despite Aixola being a small (4.6 km^2) and forested watershed, the model calibration (2007–2010) and validation (2005–2006) results were rated as satisfactory. Nevertheless, daily flow and sediment peaks were underestimated by the model. The aim of this paper is to assess the correct simulation of hydrological processes in Aixola watershed using SWAT in order to 1) point out where the highest uncertainties or errors in the simulation results occur (surface/groundwater contribution, spatial and temporal distribution) and 2) assess whether it is possible or not to obtain good results in the outlet along with a good approximation of the water contribution from different parts of the watershed. With that purpose the measured electrical conductivity (10/01/2011-12/31/2012) was used to estimate the water contribution from the two main subwatersheds and these data were compared with the results obtained from the model. SWAT invariably simulates more streamflow in the biggest subwatershed (around 30 % more) although in observed data, contribution of subwatersheds is much more changeable. Additionally, electrical conductivity measured in the outlet of the Aixola watershed was used to perform a decomposition of the hydrograph considering superficial runoff and subsurface + groundwater runoff. Obtained data were compared with those of groundwater and surface runoff simulated by the model and theresults showed a good performance of the SWAT.

Keywords

SWAT model, hydrological processes, groundwater, surface runoff, electrical conductivity, contribution.

Obstacles and Pitfalls in Simulating the Water Balance of Lake Victoria Catchment

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Abstract

The White Nile River Basin is one of the most complex hydrological systems worldwide. It is extremely challenging to include all the lakes (Lake Victoria, Kyoga, George, Edward etc.) and riverine wetlands and papyrus swamps into hydrological models in a process-based approach. The integration of these natural structures is particularly important in studies that intend to assess possible impacts of climate change and/or land and water management on water resources. Lake Victoria can be considered as the international source of the White Nile. Its catchment covers an area of approximately 260,000 km2 and is the subject of this study. The lake itself has an area of ~60,000 km2. Modelling the outflow of Lake Victoria requires to adequately simulate its inflows from various streams and to consider the lake as a huge reservoir. Where a reservoir module, providing different control options, accounts for the latter, a wetland module was integrated into the SWIM model to represent the basic hydrologic processes in riverine wetlands. The extent and location of wetlands were identified from a land use map and those areas act as storage that delays streamflow from the respective subbasin and accounts for increased evapotranspiration and ground water recharge. Including these wetland specific functions into the hydrological model avoids unrealistic model parameter settings that would most likely distort model results in the context of scenario impact studies.

Modeling river discharges of the heavily managed Limpopo river using SWIM and the open-source datasets

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Abstract

The Limpopo river is considered as one of the most vulnerable areas to climate change in Africa as suggested by the global-scale climate impact studies. This invokes further research on this river using regional-scale models. However, it is a big challenge to simulate the Limpopo river using hydrological models due to poor local data and the strong interferences by water management. Moreover, the average annual runoff generation is about 13 mm only, so even minor influences, such as water and land management or climate change, can lead to significant changes in river discharges.

For such a complex river basin, this study shows how well the eco-hydrological model SWIM (Soil and Water Integrated Model) can simulate the river discharge using global open-source datasets and the management information available in the internet. Firstly, the SWIM model was applied directly ignoring the human influences. It was found that the model can be still calibrated to provide satisfactory results but with unreasonable settings of some parameters. To solve this problem, a reservoir module and a simple water abstraction (for irrigation) function were included in the SWIM based on the internet data. Although the estimation of human interferences cannot represent the total anthropogenic influence on river discharges, it indeed helped to achieve well comparable results using a more reasonable parameter setting. Hence, the global dataset and the internet information could be very useful for hydrological modeling in the large-scale and data-scarce regions. Finally, the results of climate impact assessment for the basin will be presented.

Hydrological Modelling of Bagmati River Basin using SWAT model

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Abstract

Hydrological modeling of a river basin by a suitable hydrological model is an essential component of a water management system. Developments in computer technology have revolutionized the methodology of hydrological modeling for efficient water management. In present scenario hydrological models can be classified as GIS-based models and stand-alone computer aided models. Distributed parameter models have large input data requirements. Geographic information systems (GIS) aid the efficient creation of input data ?les required by such models. Soil and Water Assessment Tool (SWAT), is a distributed parameter GIS-based model developed by the United States Department of Agriculture. It has unique potential to integrate different components of hydrology, hydraulics, and climatology to provide real sustainable solutions for problems of nature and natural calamities such as floods and droughts. This paper describes application of SWAT model for hydrological modeling of Bagmati River Basin of Bihar, India. The SWAT model requires data on terrain, land use, soil, and weather for assessment of inflows and outflows of reaches. SRTM – DEM (90 m resolution), landuse of global USGS (2 M), Soil of FAO Global soil (5 M) and aphrodite gridded rainfall data have been used for running SWAT model. For calibration and validation of model observed data have been collected from CWC, WRD (Water Resource Department) and IMD (Indian Meteorological Department). Seventeen parameters were selected for sensitivity analysis, calibration, validation and uncertainty analysis to be carried out by SWAT-CUP4 using SUFI algorithm. On the basis of global sensitivity analysis it can be concluded that most sensitive parameter for Bagmati River Basin is curve number followed by groundwater delay time, manning's coefficient, soil evaporation compensation factor, and average slope steepness, threshold water level in shallow aquifer for base flow, aquifer percolation coefficient and SURLAG. P-factor and r-factor for calibration were found to be 0.74 and is 0.44 respectively, which are very much within the range recommended for a perfect model. Seventy four percent observed and simulated values lie in 95PPU. P-factor and r-factor for validation period are 0.63 and 0.36 respectively which are satisfactory. Nash-Sutcliffe coefficient for calibration of model for Hayaghat gauge station was found to be 0.95 which indicates the best performance of the model. Nash-Sutcliffe coefficients for validation of the model for daily simulation for years 2004 and 2010 were found to be 0.93 and 0.91 respectively. In its present form SWAT cannot be used for modeling a hydrological event for providing real time flood forecast type of applications. Hence some modifications have been done in SWAT2005 for hourly simulation and event based modeling. Also an ARIMA error model has been developed for forecasting error. For hourly flows for years 2004, 2005, 2010, and 2011 Nash-Sutcliffe coefficients were found to be 0.65, 0.84, 0.74, and 0.64 respectively which are within the range for good performance. After applying correction in errors by ARIMA model Nash-Sutcliffe coefficients for hourly simulations of flows of year 2004 and 2005 were found to be 0.79 and 0.89 respectively which indicates that error in hourly simulation can be minimized by ARIMA model to a great extent.

Keywords: SWAT, SWAT-CUP4, sensitivity, uncertainty, calibration, validation

Water resources quantity and quality in Black Sea Basin

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Abstract

Increasing water demand and conflict of interest presents a huge water management challenge in the Black Sea Basin (BSB). An integrated management of water is being sought, which requires a new level of consideration where water bodies are to be viewed in the context of the whole river system and managed as a unit within their basins. A frequently advocated approach is to have adequate knowledge of temporal and spatial variability of the fresh water availability and water quality in the basin. To achieve this, we used the program Soil and Water Assessment Tool (SWAT) to model the hydrology of the BSB with an area of 2.3 million km^2. The hydrological model of the BSB was calibrated, validated, and sensitivity and uncertainty analysis were performed to assess the goodness of modeling results using the Sequential Uncertainty Fitting program (SUFI-2). River discharges were used for model calibration. Grid technology was successfully tested for such a large model to improve calibration computation time by more than an order of magnitude. We calculated all components of water cycle using the calibrated hydrological model. In this paper we particularly discuss the challenges of building a large-scale model in fine spatial and temporal detail and show the strengths and pitfalls of such modeling tasks.

Keywords

Hydrology, Large scale, Calibration, Uncertainty, SWAT, SUFI-2, Grid computing

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