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2012 International SWAT Conference

Indian Institute of Technology Delhi

2012 International SWAT Conference

18-20 July, 2012

India Habitat Centre, Lodhi Road, New Delhi, India

Book of Abstracts

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Director's Message

It is a proud privilege and honour for IIT Delhi to host the 2012 International SWAT Conference. It is indeed a prestigious event and is being held for the first time in South & South East Asia. It gives me immense pleasure in welcoming all the delegates to this ancient city.

SWAT (Soil and Water Assessment Tool), is a sophisticated basin scale model used widely for solving problems related to water resources planning and management and more recently in climate change studies. It equips the users from various fields in predicting the impacts of weather, soils, land use and land management practices on water supplies and pollution as well as soil erosion, fertility and crop production etc. IIT Delhi has been participating in the development and enrichment of the model since the last 14 years after concurring MoA with Texas Agricultural Experiment Station, College Station, Texas and using this model for hydrologic modelling of various Indian River Basins.

Scientists, technologists and students from all around the globe shall be meeting at Delhi to facilitate the global exchange of ideas and knowledge in the field of Water Resources and allied areas. I extend my best wishes to all participants and wish the conference a grand success. I am sure that all the participants will benefit academically and socially from this event.

Prof R K Shevgaonkar

Preface

I am delighted that Department of Civil Engineering, IIT Delhi is hosting the 2012 International SWAT Workshops and Conference during July 16-20, 2012 at New Delhi. This is a very coveted and eagerly awaited event.

The untiring efforts of Jimmy, Jeff and Srini saw the initial versions of SWAT (Soil and Water Assessment Tool) to reach a stage in nineties where the user and developer community across the Globe started accepting the SWAT as a product worth using. The popularity was not only due to the fact that it was a very robust model, which indeed it is, but also because of the fact that they very sincerely extended a helping hand to whosoever wanted to use it and even participate in its enhancement. While doing so they not only have helped tens of hundreds of scientists but also championed the philosophy of development of the mathematical models that are essential to solve many of the recent problems of water resources in a transparent manner where everybody is welcome to participate in any capacity. I still remember like yesterday, although it was in 1996, when I approached Srini and Jeff that IIT Delhi shall like to use the model. The reply was so positive and warm that a bond was created which is still going strong till today.

By the end of the twentieth century the number of such users had already grown to a sizable number. In 2001, it was contemplated to create an opportunity where researchers and modelers from various countries can meet and share their ideas and experiences. Thus, the first conference was held in 2001 in Germany. Since then SWAT conference has become a regular affair. Subsequent conferences have been held in Italy, Switzerland, China, The Netherlands, Korea and the last being in Spain in 2011.

The SWAT workshops have also become a part and parcel of these events where many of the budding researchers are inducted into the use of SWAT model to solve the problems being faced in their countries.

For those who are still not connected to the model, SWAT is developed by a group of scientists from the United States Department of Agriculture - Agricultural Research Service (USDA-ARS); the United States Department of

Agriculture - Natural Resources Conservation Service (USDA-NRCS) and Texas AgriLife Research. It was developed to predict the impact of land management practices on water, sediment and agricultural chemical yields in large complex watersheds with varying soils, land use and management conditions over long periods of time.

This year, the Department of Civil Engineering, IIT, Delhi has been honoured to host this global event. It is for the first time that Non-SWAT papers have also been allowed in the conference to allow researchers working in the area of water resources to interact with the SWAT community.

Department of Civil Engineering, IIT Delhi has been using SWAT for various hydrologic and climate change studies over the last fifteen years. The SWAT has been used to make the National Communication of India to the United Nations Framework Convention on Climate Change (UNFCCC) for quantifying the possible impact of the climate change on the water resources of the country as well as vulnerability assessment and adaptation options – national project undertaken by the Ministry of Environment and Forests (NATCOM Project Phase I & II). The work has been disseminated to the potential users through a specially designed GIS based site (http://gisserver.civil.iitd.ac.in/natcom).

I extend a warm welcome to all delegates who have come from all around the globe for this event and I believe that this forum will provide a platform to existing members to interact with their peers and inspire an enthusiasm in new participants by widening their understandings in the field of hydrology. I wish them all gainful interactions and happy and healthy stay at Delhi during the workshops and conference.

Prof. A. K. Gosain

Dr. Jeff Arnold

U.S. Dept. of Agriculture-Agricultural Research Service

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.

His research experience is from 2007 2010, GS 15, Research Leader, USDA, ARS, Temple, TX; 1992 2006, GS 13-15, Agricultural Engineer, USDA, ARS, Temple, TX; 1989 1992, GS 12, Agricultural Engineer, USDA, ARS, West Lafayette, IN; 1983 1989, GS 9-11, Hydraulic Engineer, USDA, ARS, Temple, TX. He was responsible for annual budget exceeding $3.5 million. Technical and administrative supervision is provided for 8 ARS scientists, 3 post-docs, 17 technical support staff, 4 administrative staff, and 3 Texas Agricultural Experiment Station research scientists.

Jeffrey G. Arnold has achieved international recognition as a leading authority in watershed model development and environmental assessment. He has been engaged in research for 28 years with ARS, and has prepared 225 research articles, including 130 refereed scientific journal articles and 10 invited, refereed book chapters. There are currently over 900 articles in the peer reviewed scientific literature related to SWAT model development, validation, conservation assessment, environmental policy, and climate change analysis. He has been invited to present research at 46 national and international meetings with 12 of those international and 1 international keynote presentation. Incumbent is leading international watershed model development as evidenced by leading four international SWAT conferences in Europe. Because of his international reputation, twenty-three scientists from seventeen countries have come to work with the incumbent. He is having major impact on USDA conservation policy and EPA environmental policy by leading watershed components of national conservation assessments (CEAP-Conservation Effects Assessment Project) and by his models being used across the country for watershed planning.

Dr. Tishyarakshit Chatterjee

Secretary, Ministry of Environment & Forests

Dr. T Chatterjee is an IAS of 1975 batch. He has a Bachelor's in History & Economics, a Masters in History from St Stephen's College, a P.G. D. in International Development and Cooperation from University of Ottawa, Canada. Dr. Chatterjee has a Ph. D. in Economics (Environment) from Hyderabad Central University.

Prior to assuming charge as Secretary, Union Ministry of Environment and Forests, GoI, in 2011, Dr. Chatterjee has also held numerous other important positions which include (i) Director, Environment Protection Training & Research Institute (EPTRI), Hyderabad (1993 to 1997); (ii) Member Secretary, State Pollution Control Board, Andhra Pradesh, India (1997 to 2002); (iii) Principal Secretary, Municipal Administration Department, Government of Andhra Pradesh (June 2002 to June 2003); (iv) Principal Secretary, Environment and Forests, Government of Andhra Pradesh (June 2003 to May 2006); (v) Principal Secretary, Roads and Buildings Department, Government of Andhra Pradesh (June 2006 to Dec 2009); (vi) Special Chief Secretary, Planning Department, Government of Andhra Pradesh (Jan 2010 to Jan 2011)

Dr. Chatterjee's significant achievements in the area of Environmental Management include the setting up of India's first two PPP based initiatives in 1999 for common bio-medical waste management. He is also responsible for setting up India's first industrial hazardous (solid) waste common management (TSDF) facility in 2001. Besides having authored many important publications, Dr. Chatterjee has also led the initiative to prepare Environmental Zoning maps in 50K scale for all development corridors of AP state.

Dr. Shailesh Nayak
Secretary, Ministry of Earth Sciences

Dr. Shailesh Nayak is the Secretary, Union Ministry of Earth Sciences, GoI since August 2008 and has played a leadership role in the formulation of various programmes such as climate change, weather services, polar science, ocean survey and modeling.

Dr. Nayak joined the Space Applications Centre, Indian Space Research Organization (ISRO) in 1978 as a scientist and earned a doctorate degree in Geology from the M.S. University, Baroda, in 1980. As Director of Marine and Water Resources, he was mainly responsible for conceptualizing, formulating and executing many national level projects related to application of satellite data on ocean colour, integrated coastal zone management, snow and glacier studies and water resources.

In May, 2006, Dr. Nayak was appointed as Director, Indian National Centre for Ocean Information Services (INCOIS), an autonomous institution under the Ministry of Earth Sciences, Hyderabad where he set up a state-of-the-art 'Early Warning System' for tsunami and storm surges in the Indian Ocean. He was also responsible for the conceptualization and development of Marine GIS and made outstanding contributions in improving advisory services related to potential fishing zones, ocean state forecast, and Indian Argo project.

Dr. Nayak has chaired numerous committees and expert groups including (i) expert group set up to establish National GIS for India; (ii) Research Advisory Committee of the National Institute of Oceanography, Goa; (iii) Centre for Earth Science Studies, Thiruvananthapuram; (iv) Governing Board, Birbal Sahni Institute of Paleobotany, Lucknow; (v). Currently, Dr. Nayak is the Chairman of Regional Integrated Multi-hazard Early Warning System (RIMES) and the Indian Ocean Observing System Resource Forum (IRF), and the President, Indian Meteorological Society (IMS). Earlier, he has also been (i) Vice-Chair of the Inter-Governmental Coordinating Group on Indian Ocean Tsunami Warning System (ICG-IOTWS) (2007-2011); (ii) President of ISRS, Dehradun; (iii) Chairman, Indian Ocean–Global Ocean Observing System (IO-GOOS) for the term 2006-2010; (iv) President, ISPRS Technical Commission (TC) IV on 'Geo-databases and Digital Mapping' for the term 2004-08 and has also represented Indian Space Research Organization (ISRO) in the International Ocean Colour Coordinating Group and International Global

Observation Strategy-Coastal Theme.

Over the years, Dr. Nayak has been bestowed with numerous awards and accolades in recognition of his achievements in Earth Sciences including (i) Indian National Remote Sensing Award for 1994; (ii) National Mineral Award for the year 2005; (iii) Bhaskara Award for 2009; and (iv) ISC Vikram Sarabhai Memorial Award 2012. Dr. Nayak has published about 80 papers and atlases in National and International Journals of repute and has also supervised six Ph. D. theses. In recognition of his scientific contributions, Dr. Nayak was awarded an Honorary Doctor of Science by the Andhra University in 2011 and has also been nominated as Fellow of the Indian Society of Remote Sensing (ISRS) in 2011 and Fellow of the International Society of Photogrametry and Remote Sensing (ISPRS) in 2012. Dr. Nayak is also the Editor of Geospatial Today, Member of the Editorial Board of the Indian Journal of Marine Science, and currently holds the Chair of Planet Earth.

Shri P. J. Joseph

Hon'ble Minister for Water Resources, Govt. of Kerala

Shri P. J. Joseph has had a distinguished career in Politics and Government. Prior to his membership of the 12th Kerala Legislative Assembly, Shri Joseph has also been an honourable member of the 4th, 5th, 6th, 7th, 8th, and 10th Kerala Legislative Assemblies. Shri P. J. Joseph is an Economist by training having earned a B.A. (Economics) from Loyola College, Chennai followed by a M.A. (Economics) from Sacred Hearts College Thevara, Kochi.

In recognition of his able leadership qualities and a deep understanding of social challenges, Shri Joseph has been at the helm of affairs in important ministries and include tenures as Minister for Home Affairs from Jan-1978 to Sep-1978, Minister for Revenue & Education from Dec-1981 to Mar-1982, Minister for Revenue and Housing from May-1982 to Mar-1987, Minister for Education, Public Works, Housing & Registration from May-1996 to May-2001, Minister of Public Works from May -2006 to Dec-2010 and currently holds the important portfolio of Minister for Water Resources since May-2011.

Shri P. J. Joseph is a Member of Kerala University Syndicate – 1975, and, in the past, has also held the positions of Working Chairman, Kerala Congress Party, Chairman, Gandhiji Study Centre, and Member, Indian Science Congress.

Shri P. J. Joseph is a multifaceted personality and has a passion for reading, travelling and singing. His other interests also include bio and organic farming and dairy farming. Shri Joseph is widely regarded as a pioneer in bio-farming and organizes the annual Karshikamela (Agricultural Fest) in Thodupuzha.

Dr. Raghavan Srinivasan

Professor, Texas AgriLife Research
Texas A&M University
Spatial Sciences Laboratory

Dr. Srinivasan has a Ph. D. (1992) degree in Agricultural Engineering from Purdue University; M.S (1989) degree in Agricultural Engineering from Asian Institute of Technology; B.E (1984) degree in Agricultural Engineering from Tamil Nadu Agricultural University. As a professor in the departments of Ecosystem Science and Management, and Biological and Agricultural Engineering at Texas A&M University, Dr. Srinivasan has continued to transfer his sphere of knowledge and experience to his students over the past 12 years. Through research over 22 years, he has had the opportunity to share current spatial science technology as applied to water resources management with society by providing leadership, technical knowledge, and service through participation in local, national, and international organizations.

Dr. Srinivasan headed a continental scale project called Hydrologic Unit Model for the United States (HUMUS) that provided information for 1997 Resources Conservation Act (RCA) funded by USDA. He has developed the interfaces to make use of watershed models such as SWAT on various GIS platforms such as GRASS, ARCVIEW, and ArcGIS. He was responsible for integrating SWAT as one of the water quality models into EPA's BASINS framework and also in developing various spatial tools on automated watershed delineation, landuse-soil definitions for subwatersheds, map grid projection and calibration for BASINS. Dr. Srinivasan is currently leading several national and international water quality modeling projects at various spatial and temporal scales.

Dr. Srinivasan has published more than 120 peer reviewed publications, 5 book chapters, several hundred national and international conferences and professional meeting presentations and has earned wide recognition and numerous awards at Laboratory, Research Center, University and State levels for his scientific contributions. As a further recognition of his scientific contributions, Dr. Srinivasan holds membership of prestigious academic societies such as American Society of Agricultural Engineers (ASAE), and American Water Resource Association (AWRA) besides serving as an Associate Editor for Journal of Environmental Quality.

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Dr. A.K. Gosain, Indian Institute of Technology Delhi

Dr. Balaji Narasimhan, Indian Institute of Technology Madras

Dr. Jeff Arnold, USDA-ARS, USA

Dr. R. Srinivasan, Texas AgriLife Research, Texas A&M University, USA

Ms Courtney Smith, Texas AgriLife Research, USA

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Impact of Recharge Sources on Isotopic Composition and Microbiological Quality of Groundwater-A Case Study from Punjab, India

Gopal Krishan[2],Saroj Kumari[1], M S Rao[2], Shyam Lal[2] and Padma Singh[1]

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Abstract

A study was conducted to find out the impact of recharge sources on isotopic and microbiological quality of groundwater in a transect of Hoshiapur district of Punjab, India. The water samples were collected from deep and shallow regions and were subjected to isotopic and microbiological analysis.

The groundwater salinity in deep aquifer follows a narrow range (510 S/cm to 660 S/cm) compared to that at shallow aquifer groundwater (760/cm to 1960 S/cm). The results of microbiological analysis show that deep water contains higher number of bacterial population than shallow water. The isotopic composition in shallow groundwater ranged from -4.49% to -5.87% for 18O & -35.24% to -39.57% for D and in deep groundwater the values of 18O ranged from -4.79% to -7.01% and D ranged from -38.50% to -43.24%. The isotopic values of the deeper aquifers were more depleted than the shallow aquifers.

The integrated studies clearly show that (i) using isotopes groundwater recharge source and interaction between shallow and deep aquifer can be monitored, (ii) bacteriological colonies can infilterate and contaminate even deep aquifers whenever there is interaction between shallow and deep groundwater., (iii) the pollution due to anthropological influence changes groundwater salinity and also cause bacteriological contamination of groundwater and (iv) natural freshwater recharge freshens the quality of water and the length over which freshening results depends upon level of pre-contamination and fresh water recharge conditions.

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Application of SWAT Model to an Agricultural Watershed in Tamil Nadu, India

E. Arun Babu[1], B. Suresh [2], S. Ravichandran[3]

[1]Assistant Professor , [2]PG Student, [3]Professor, Centre for Water Resources, Anna University, Chennai, India

Abstract

This study aims to apply and validate SWAT model in an agricultural watershed to understand the processes involved in soil erosion that reduces the reservoir quantity and quality. Eroded soil from the watershed acts as a carrier for the transport of nutrients from the agricultural fields which promotes (algal bloom) eutrophication process largely.

Krishnagiri Reservoir Project is one whose water quality is deteriorated due to serious soil erosion problems. Arc SWAT 2009 was applied to Krishnagiri Reservoir Watershed located in the northwestern part of Tamil Nadu, India. The watershed has a total area of 2500 km2 with elevation varying from 540m to 1200 m above Mean Sea Level with the yearly average precipitation of 995 mm. The predominant land use is agricultural plantation, industries, forest, water bodies and hills.

SWAT divided the watershed into Hydrological Response Units by merging Digital Elevation Model, Land use and Soil pattern. The model was calibrated (2000 to 2005) and validated (2006 to 2010) using the measured discharge and sediment load from a gauge station. Calibration and validation showed a satisfactory agreement between the measured monthly flow with simulated monthly flow. Nash–Sutcliffe coefficient (NSE=0.8) and Root Mean Square error (R2 =0.9) are used to evaluate the performance of the Model. This study reveals the areas of sediment sources from the watershed which helps in adopting a suitable soil conservation measures in the watershed.

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Simulation of Streamflow in a Humid Tropical River Using SWAT

Celine George

Abstract

The main objective of the study was to test the performance and feasibility of SWAT 2005 model for prediction of streamflow in Meenachil river basin, Kerala. The model was calibrated and validated for three gauging stations, viz., Peroor, Pala and Cheripad. The model was autocalibrated for a period of 13 years (1982 – 1994) using SWAT CUP software. The SUFi2 algorithm in SWAT CUP was adopted for autocalibration of the model. The calibrated model was validated for the three gauging stations for a period of 10 years (1995 – 2004). The landuse map used for the calibration period was for the year 1990 and that for the validation period was for the year 2000. The simulated monthly streamflow has Nash Sutcliffe efficiency value of 0.81, 0.80 and 0.80 for the calibration period for the Peroor, Pala and Cheripad stations respectively. The model was successful in simulating streamflow during validation period as indicated by Nash Sutcliffe efficiency value of 0.69, 0.77 and 0.77 and R2 value of 0.84, 0.83 and 0.78 respectively for Peroor, Pala and Cheripad stations. The model results in good performance showing that it is feasible for predicting streamflow in Meenachil river basin under changing landuse and climate conditions.

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Hydrological Modelling of Small Watersheds of South Ponnaiyar Basin in the Soil and Water Assessment Tool (SWAT)

Dr. B.S. Polisgowdar

Abstract

A widely tested SWAT model was applied to the monthly runoff and sediment yield of two gauged agricultural watersheds of Tamil Nadu. The watershed and subwatershed boundaries, drainage networks, slope, soil series and texture maps were generated using a geographical information system (GIS). A supervised classification method was used for land-use/cover classification from satellite imageries. The calibration and validation of SWAT for prediction of runoff and sediment yield at Poyyapatti (7445.07 hectare area) and testing the validity of the calibrated model to Nallur watershed (2150.58 hectares area) of South Ponnaiyar river basin in Tamil Nadu was performed. The input parameters viz., Curve number for AMC-II, Soil available water capacity, Universal soil loss equation C factor & P factor, Mannings' n for tributary channel and main channel, Effective hydraulic conductivity for tributary channel alluvium and Effective hydraulic conductivity for main channel alluvium were selected for calibration of runoff and sediment. The Coefficient of Determination, Nash-Sutcliffe Coefficient, Root Mean Square Error and Percent Deviation were used to test the validity of predicted monthly values of runoff and sediment yield rates. The model performance was very good in simulating runoff and sediment yield during calibration and validation period (2005-08) at Poyyapatti. The validated model performance was observed to be good for simulating monthly runoff and sediment yield at other watershed during the period 2004-08. Therefore, it can be concluded that the SWAT model could be used for developing a multiple year management plan for the critical erosion prone areas of small watersheds.

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Applying SWAT to a Watershed Containing Paddy Fields with Soil-Profile Physical Properties Dataset

Atsushi Sakaguchi[1], Sadao Eguchi[1] and Masahiro Kasuya[2]

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[2]Aichi Agric. Res. Cent., 1-1 Yazakosagamine, Nagakute, 480-1193, Japan

Abstract

Rice cultivation in paddy fields is a typical agricultural management system in Monsoon Asia and significantly affects the regional hydrology and water quality. SWAT is a popular tool in upland cropping area, and becoming popular in Monsoon Asia. Lately, researchers are assessing the impact of paddy rice cultivation by applying SWAT; however, certainty of the assessment by SWAT which has developed for upland fields is not clear.

In this study, the hydrological process of a watershed containing paddy fields was examined by soil physical approach in SWAT as a first step of comprehensive assessment including SS, nutrients and so on. In this approach, we used the Green-Ampt infiltration method with SolphyJ (soil-profile physical properties database of Japan), daily irrigation data, 10-minutes rainfall data, average size of terraced paddy field, and standard irrigation and drainage management. We did not use the SCS curve number procedure, commonly used for assessment of watershed containing paddy fields, for it is quite difficult to find out appropriate constant curve number value for paddy field soils because the runoff characteristics largely change with management. Moreover, hydrology of paddy fields is too complicate to use heuristics. To express the irrigation into paddy fields, two ways were attempted: the first was using Pothole and the second was irrigating upland field HRU regarding it as paddy.

As a result, the subsurface percolation in irrigated paddy fields calculated by both ways was very smaller than the field observation. To assess the hydrology in watershed containing paddy fields by SWAT, the algorism of seepage and irrigation should be improved to allow percolation even the first soil layer is saturated more than the field capacity. On the other hand, it seemed to be available for upland fields even under the Monsoon climate.

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Precision Orchard Management System and Erosion Control

Prof. János Tamás

Abstract

Modern geographical information programmes and databases make possible to create such data systems with more detailed data than earlier, which can be analysed for precision agriculture, erosion control point of view. By using applied GIS methods, the spatial distribution of physical and water management properties of soils were surveyed in this study, in order to examine erosion risks in orchards and to supply complex research activities in precision farming.

The research field was an 80 hectare Bosc and Williams pear orchard in the South Western part of Hungary. Row distance is grassed, and the orchard is irrigated. In the course of the field work the spatial position and individual extent of all pear trees was defined to set up a detailed GIS data base. The established geographical information system of the pear plantation contains the name of species, data of plantation circumstances, soil parameters, and the properties of the fruit trees. This datasets are appropriate tool for precision irrigation and nutrition system. To evaluate the effect of erosion, three dimensional digital terrain models were produced and GPS based soil samples were taken from the surface. Both soil physical (soil plasticity) and chemical (pH, NPK and soluble microelement contents of soils) characteristics of the samples were measured in the laboratory.

This study integrated site spatial data sets became the basis for a precision spatial decision support system. Therefore those sites were determined where erosion risk is high, the increasing intensity of runoff caused faster nutrient and microelement leaching, liming is needed.

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NutriL-GIS: A Stand-alone Modelling Tool for Non-point Source Pollution Assessment

Aabha Sargaonkar

Abstract

Agricultural runoff is one of the major contributors to non-point source (NPS) pollution of surface and groundwater resources. Rsearch during past decade has shown that nutrients viz. nitrogen (N) and phosphorus (P) cause eutrophication in water bodies, odour problems, unaesthetic view and imbalance in aquatic habitats. High concentration of nitrate in drinking water causes methamoglobinemia or "blue baby syndrome" a potentially fatal disease in infants, indicating need to protect drinking water sources.

Assessment of NPS pollution load to prioritize the watersheds for implementation of Best Management Practices (BMPs) can help protect water resources. Literature reveals thatmathematical models considering spatial database and hydrological analysis tools have been developed for this purpose. However, a common criticism is that most of the models are data intensive and require knowledge of hydrology as well as Geographical Information System (GIS) for pre-processing of data and post-processing of modeling results. This limits their applicability in decision making for watershed management.

NutriL-GIS is a hydrological modeling tool developed for assessment and quantification of agricultural runoff and nutrient load in a watershed. It is a user-friendly, stand-alone application that incorporates GIS features and functionalities for data analysis and computing. Three computational modules of NutriL-GIS are: Runoff Estimation (RunEstim), Agricultural Data Analysis Module (ADAM) and Nutrient Load Estimation Module (NutriLEM). RunEstim simulates rainfall-runoff in a watershed based on a popular empirical model Soil Conservation Service Curve Number (SCS-CN) method that takes into account runoff producing characteristics of land. ADAM estimates Event Mean Concentration (EMC) of nutrients in the runoff from agricultural land and NutriLEM estimates distributed nutrient load in a watershed. Application of NutriL-GIS for a case study is presented in this paper.

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Synergistic Impacts of Land-use Change and Soil-Property Variation on Non-point Source Nitrogen Pollution in a Freeze-thaw Area

Quantifying the non-point source (NPS) nitrogen pollution response to the varied land uses and soil properties in highly agricultural regions is critical for the proper management of NPS pollution. This study modeled the NPS nitrogen loading responses to variations of land use and soil from 1979 to 2009. The Soil and Water Assessment Tool (SWAT) was used to model the NPS organic nitrogen and nitrate loading in a freeze-thaw area in northeast China. The temporal-spatial simulations of land use in four periods indicated that the NPS nitrogen loading responded to the disappearance of wetlands and the conversion of uplands to paddy rice. After updating the soil data, the watershed NPS nitrogen loading decreased, and the spatial distribution of the loading indicated that the NPS organic nitrogen was more sensitive than was the nitrate to soil variation. F-tests were employed to assess the significance of each of the predictor variables in five types of simulations. Overall, the results indicate that the watershed NPS nitrogen loading is sensitive to changes of soil and land use, but soil changes have a more significant impact. The results of this study also suggest that temperature has significant effects on NPS nitrogen yield and that it caused the twin peaks in the temporal scale. Increasing the temperature above zero in April caused a temporal shift in soil water movement and transported nitrogen pollution earlier in the year, causing an increased loading in water before the summer irrigation, which is advantageous for NPS nitrogen pollution control.

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Modeling Climate Change Impacts on Hydrology of a Small RVP Watershed of Southern India

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Abstract

The Soil & Water Assessment Tool (SWAT) was used to simulate hydrological responses from Kundhichira watershed (6016 ha) located within Kabini River valley (RVP) catchment of South India. The DEM has been derived from the ASTER data at 30 m resolution and was appropriately processed using actual digitized stream network from Google earth. The land use map using Landsat ETM 7+ satellite imageries. The soil database was created for various soils as per All India Soil & Land Use Survey (AISLUS) report No. Agri.834/91 of Govt. of India. The model was setup with 33 sub-basins and 299 HRUs. Monthly observed runoff records from 2003 to 2006 were used to calibrate the model where as the validation of the model was carried out using the monthly records from 2007 to 2009. Sequential uncertainty fitting (SUFI ver2) procedure implemented through SWAT-CUP v2009 was used for calibration and validation. The simulation was found to be effective in representing the watershed hydrological responses with reasonably good modeling efficiencies (ME) of 0.799 during calibration and 0.822 during validation. Monthly projections for the period of 2071-2100 downscaled PRECIS model run for Indian condition under the scenarios representing intermediate emissions (A2a) were used to describe the projected hydrological scenario. It was found that under the same cropping pattern and management activities, surface runoff and total sediment load, Water yield, PET and ET are likely to increase by 1.56%, 20.8%, 2.01%, 18.75% and 6.76 % respectively under projected condition with increase in rainfall by 2.97 %.

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Evaluating the Change of Hydrological Processes and Sediment Yield Considering the Effect of Climate Change

Dao Nguyen Khoi

Abstract

In this study, we investigated the response of hydrology and sediment yield under the impact of climate change scenarios in Be River Catchment, using SWAT hydrological model. The calibration and validation results indicated that SWAT model is a powerful tool to simulate the impact of environmental change on hydrology and sediment yield in this catchment. Based on the model calibration and validation, the hydrologic and sediment yield response to climate changes was simulated. Climate change scenarios (A1B and B1) were developed from an ensemble of four GCMs (CGCM3.1 (T63), CM2.0, CM2.1 and HadCM3) that showed good performance for the Be River Catchment through statistical evaluations between 15 GCM control simulations and the corresponding time series of observations at annual and monthly levels. Under the climate change scenarios, the results indicated that climate change in the catchment leads to decreases in streamflow (1.9 – 3.7%), groundwater discharge (4.5 – 5.8%), and sediment load (0 – 4.4%), increase in evapotranspiration (0 – 8.0%), and changes in surface runoff (-2.3 – 1.8%). Furthermore, the results also emphasized water scarcity during the dry season and increase of soil erosion in the wet season.

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Hydrological Response to Climate Change in the Krishna Basin

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Abstract

In this study, impacts of climate change on water balance components in the Krishna river basin are investigated. Semi-distributed hydrological model namely Soil and Water Assessment Tool (SWAT) has been used. The 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. The framework predicts the impact of climate change on the hydrological regime with the assumption that the land use shall not change over time and any manmade changes are not incorporated. Simulation at 23 sub-basins of the Krishna basin has been conducted with 30 years of data belonging to control (present) , for the remaining 60 years data (2011-2040) and (2041-2070) were corresponding to GHG (future) climate scenario. Quantification of climate change impact has been done through the use of SWAT hydrological model. The initial analysis has been predicted,the increase in precipitation in almost half of the month of the year and decrease in precipitation in the remaining months. The future annual discharge, surface runoff and base flow in the basin show increases over the present as a result of future climate change.

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GIS Based Hydrological Modelling for Climate Change Impact Assessment

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Abstract

In the present study, GIS based hydrological modeling has been used to assess the impacts of climate change on the hydrological regime of Cauvery river basin in India. The hydrological model used for the study is SWAT (Soil and Water Assessment Tool). The analysis has been carried out in three stages. In the first stage, the impact of changes in the land management practices on the water availability in the basin under the present conditions has been modelled. In the second stage, the same analysis has been carried out under the future climatic conditions. The future climate change scenarios have been generated using the daily weather series generated by Hadley Centre, UK (HadRM2). In the third stage, an analysis has been carried out for comparing the annual and monthly precipitation variabilities under the present as well as the futuristic climate change scenarios. The results indicate intensification of the hydrological cycle in the future climate change scenario, which appears to be significant on an annual basis. The study demonstrates that simulation modelling can play a very significant role in conflict resolution by generating a series of scenarios or options for the stakeholders, so as to enable them to take sound rational decisions. Also, implications of climate change on the availability of water in the shared watercourse and consequently, share of each riparian state, can be analysed using modelling techniques.

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Disclaimer: The views expressed in the paper are strictly individual views of the authors and do not, in any way, represent the views of the organizations where they are presently working.

Management Scenario for the Critical Sub-Watersheds of Small Agricultural Watershed Using SWAT Model and GIS Technique

Dr. M. P. Tripathi

Abstract

A distributed parameter model, the Soil and Water Assessment Tool (SWAT) was tested on monthly and seasonal basis and used for developing management scenarios for the critical sub-watersheds of a small agricultural watershed (Chhokranala) of Raipur in Chhattisgarh (India). The watershed and sub-watershed boundaries, drainage networks, slope and soil texture maps were generated using GIS. Supervised classification method was adopted for land use/cover classification from satellite imagery using ERDAS Imagine. Manning's 'n' for overland and channel flow and Fraction of Field Capacity (FFC) were calibrated for monsoon season of the years 2002 to 2003. The model was validated for the years 2004 to 2005. Results revealed that the model was predicting the monthly and seasonal surface runoff and sediment yield satisfactorily. Simulation results of nutrients including organic N and P in sediment and NO3-N and soluble P in runoff were also compared with observed data for several events and found satisfactory. The critical sub-watersheds were identified on the basis of average annual sediment yield and nutrient losses during the study period. Out of seven sub-watersheds, SWS-5, SWS-6 and SWS-7 were found to be critical. Several combinations of treatment options were considered including four crops, five tillage and three levels of fertilizer. The existing management practice was considered as the base for evaluating other management practices for rice. The results showed other crops couldn't replace rice since these crops resulted in higher sediment yield as compared to rice. Considering both sediment and nutrient losses together the zero tillage, conservation tillage and field cultivator with half dose of fertilizer (40:30 of N:P kg/ha) were found to be better than the other treatments considered for evaluating their impact on sediment yield and nutrient losses for sub-watershed (SWS-5).Similar results were also noticed for other critical sub-watersheds i.e. SW-6 and SW-7.

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Runoff and Sediment Modelling of Vamanapuram River Basin

Tiji Antony

Abstract

The version of Soil and Water Assessment Tool (SWAT2005), coupled with a GIS interface (Arc SWAT), was applied to Vamanapuram River watershed located in Kerala, India. The 687 km2 drainage basin was discretized into 27 sub-basins using an automated delineation routine. The multiple hydrologic response unit (HRU) approach was used and the basin was discretized into 138 HRUs. The model simulates runoff and sediment yield for the period from January 1997 to December 2007. The model was calibrated and verified using continuous meteorological data from a station Ayilam. Calibration and verification results showed good agreement between simulated and measured data. Model performance was evaluated using statistical parameters, such as the Nash–Sutcliffe coefficient and the normalized objective function. The calibrated model can be used for further analysis of the effect of climate and land use change. The SWAT model supported by GIS technology, proved to be a very effective tool for evaluating management alternatives in river basins.

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Modelling Streamflows for Estimating Hydrological PLF of a Small Hydropower Scheme in an Ungauged Mountainous Watershed in Western Ghats in India Using SWAT

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Abstract

Ungauged mountainous watersheds of Western Ghats in India are important hydrologic systems that are responsible for much of the surface water supply and run-of-the-river hydropower schemes in southern peninsular India. The Soil and Water Assessment Tool (SWAT) has been used to model daily streamflows for a small ungauged mountainous watershed, namely, Somavathi watershed, having a catchment area of 18.56 km2. Daily energy generation has been estimated for a small hydropower scheme of 6 MW located at the outlet of the watershed, using a combination of modelled daily streamflows, differential head, turbine efficiency, and frictional losses. Model validation has been performed using sample values of daily hydropower generated from the hydropower scheme. Flow duration curve (FDCs) has been derived to assess percentile flow distributions. Corresponding hydropower energy distribution curves have also been estimated. Model performance has been evaluated using Nash-Sutcliffe coefficient (ENS), coefficient of determination (R2) and comparison of percentile hydropower obtained from observed and simulated hydropower energy distribution curves. Sensitivity analysis with Latin Hypercube One-factor-At-a-Time (LH-OAT) indicates the significance of physical soil-land use related parameters in addition to hydrometeorological parameters such as precipitation. The physical parameters found to be sensitive for simulating the ungauged wet mountainous watershed include soil available water capacity (SOL_AWC), soil evaporation compensation factor (ESCO), groundwater baseflow (ALPHA_BF), and curve number (CN2). Study shows that lateral flows from dynamic sub-surface zones in such watersheds contribute substantially to the total water yield and thereby improve the hydrological Plant Load Factor (PLF) of a small hydropower generation scheme.

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Hydrologic Modelling for the Wardha Basin

Jatin Anand

Abstract

The water resources management of a hydrosystem is a set of the decisions that impacts the status of water resources availability across the system. A Soil and Water Assessment Tool (SWAT) model of the Wardha basin was developed to assess the sub-basin's water resources availability and, further, to evaluate the impact of existing and other prospective water resources developmental initiatives on its overall water balance. The main model inputs consist of the terrain data, weather variables that include, amongst others, rainfall and temperature, and branch cycle interventions such as storage and other diversion structures. The model was calibrated manually on a daily time scale for the existing scenario and simulations were run with and without proposed future projects.

The impacts of these interventions, both existing as well as proposed, on the water balance of the basin were evaluated and quantified. The derived results suggest that there is a substantial reduction in overall water resources availability in the study basin on account of the current level of development and further, future developments, as are being proposed, may require a careful study of their potential impact on currently sanctioned water use.

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Analysis of the Impact of Water Conservation Measures on the Hydrological Response of a Medium-Sized Watershed

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Abstract

Many small water conservation measures were implemented in the upland watershedsin the Brahmaputra basin during 1990-2000 periodto enhance agro-forestry activities. The conservation measures in form of check dam with small reservoirs were built across mainly in the first-order streams, to partially harvest monsoonal stream flow. The reservoirs help in recharging the shallow ground water level, but increasing the flashiness of the watershed. Assessment of the water conservation measures on the stream flow variation is essential for sustainable water development and management. In this study, Kulsi Watershed, a medium-sized upland watershed in the Brahmaputra river(1600 km2), is considered, covering mainly upland grassland, forest, agro-forestry and shifting cultivation. The assessment of the impact of the conservation measures on stream flowis quantified by hydrological modelling for pre and post conservation periods. A semi-distributed hydrological model is first calibrated for pre-conservation period (1978 and 1985), by considering the spatial variation of topography, land use/land cover and soil. The model performance in terms of predicting monthly discharge and peak daily discharge was found to be statistically satisfactory, remaining within ± 10 percentage accuracy. The calibrated model was further used to simulate the stream flow variation for post-conservation period (1999 and 2001). The daily observed stream flowfor these years were analyzed with the simulated daily stream flow for estimating the lumped monsoonal storage and its impact on non-monsoonal flow and peak discharge. The lumped monsoonal storage is estimated about 0.25 MCM, about 20% of the total monsoonal flow (1.28 MCM). As compared to the pre-conservation period, daily peak discharge has been increased by 2 times, showing significant increase in the flashiness. Interestingly, the base flow during the non-monsoonal period has been increased by 16 % with compared to that of the pre-conservation period. In summary, use of the semi-distributed hydrological model has been demonstrated in this study to quantify the impact of large-scale water conservation measures on the streamflow.

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Hydrological Cycle Simulation of Kodavanar River (Athur Block) Watershed Using Soil and Water Assessment Tool (SWAT)

Kaviya K, Dr. M. Ramalingam

Abstract

An adequately tested soil and water assessment tool (SWAT) model was applied to the runoff and sediment yield of a small agricultural watershed in India using rainfall. SWAT was used to simulate the transport of runoff and sediment into the Kodavanar River, Tamilnadu in this study. The main objective was to validate the performance of SWAT and the feasibility of using this model as a simulator of runoff. The investigation was conducted using a 10-year historical rainfall record from Jan'88-Jan'98 for calibration and validation. Based on the water balance study the surface runoff and evapotranspiration and sediment yield were calculated and the flow duration curve was drawn and the validation work has been carried out.

The SWAT generally performs well and could accurately simulate both monthly and yearly runoff. The simulated monthly and yearly runoff matched the observed values satisfactorily, with a correlation coefficient greater than 0.9 and coefficient of determination (R2) greater than 0.95. Therefore, it can be concluded that the SWAT model could be used for developing a multiple year management plan for the critical erosion prone areas of a small watershed and planners in studying water quality problems and taking decisions.

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Stream Flow Modeling in the Nacunday River Basin (Paraguay, South America) Using SWAT Model

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Abstract

The present study is undertaken to study the stream flow behavior in the Nacunday river basin using the SWAT Model. Available hydrological data (January 1999 to September 2009) is split into two groups, one group (i.e. Jan 1999 to Dec 2005) is used for the model warm up and calibration of model parameters. The daily data of 1999 and 2000 is considered as model warm up period and the data from January 2001 up to the end of December 2005 is used for calibration of model parameters. The other group (i.e. Jan 2006 to Sep 2009) is used for validation of the model.

During the calibration, the model performance is adjudged by comparing SWAT outputs with measured stream flow using graphical comparisons and three statistical measures viz. Percent Bias (PBIAS) on annual basis, Nash-Sutcliffe Efficiency (NSE) and Coefficient of Determination (R2) both for daily and monthly basis.

During the validation period, the PBIAS remained within ±16.5% except for year 2006. Therefore on the basis of PBIAS the model performance can be rated as good except for year 2006. On monthly basis the NSE and R2 were 0.61 and 0.45 respectively and for daily basis NSE and R2 0.55 and 0.58 respectively indicate satisfactory model performance.

Although the model performance was influenced by uncertainty of the available observed data, the simulated discharge from SWAT model, both for daily and monthly basis in Nacunday watershed can be rated within acceptable range of errors, so future use of the SWAT model for various scenario testing is reasonable.

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Estimating Catchment Sediment Yield, Reservoir Sedimentation and Reservoir Effective Life Using SWAT Model

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Abstract

Sediment particles originating from soil erosion processes in the catchment are propagated along with the river flow. When the flow of river is obstructed and stored in reservoirs, the sediment settles in it and reduces its capacity. Reduction in the storage capacity of a reservoir beyond a limit hampers the purpose of reservoir for which it was designed. This sediment deposition becomes crucial for the operation of reservoirs and thus necessitates the management of catchment to control its generation. In this study, the hydrological model SWAT (Soil and Water Assessment Tool) has been employed for the assessment of sedimentation in two reservoirs (Konar, Panchet) located on the Damodar River. The model was calibrated for the period 1993-2001 and validated for the period 1997-2001 using observed runoff and sediment yield from two watersheds (Nagwan and Banikdih) within catchment and reservoirs inflow (Konar and Panchet), respectively, during the monsoon season and whole year. Validated model was run from 1993-2001 to identify critical watersheds of catchment and successfully used for prioritization of 406 watersheds contributing severely sediment to reservoirs. Reservoir sedimentation rate for Konar and Panchet reservoirs for the period 1993-2001 was found 1.12 Mm3/yr and 3.65 Mm3/yr with trapping efficiency of 94.25% and 84.4 %, respectively. Based on this analysis, it was found that Konar and Panchet reservoirs will be silted up to dead storage in another 65 and 79 years, respectively. Different management options were considered in all watersheds of the catchment to study the effects of options in controlling the reservoir sedimentation rate and thus to enhance the useful life of reservoirs. It was found that the dead storage of Konar and Panchet reservoirs would be filled completely in another 71 and 138 years when all watersheds are treated with conversation measures.

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An Integrated Modeling System to Estimate Corn Belt Region Nutrient Load Impacts on the Extent of the Seasonal Gulf of Mexico Hypoxic Zone

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Abstract

The annual extent of the seasonal hypoxic zone that forms in the Northern Gulf of Mexico, which is currently the largest in the western Atlantic Ocean, has been documented every year since 1985. The 2008 Northern Gulf of Mexico hypoxic zone covered 20,720 km2, which was the second largest ever recorded. The evidence concerning the size and duration of the zone has resulted in a growing literature describing its historical/present formation, causes, and/or effects. The 2007 USEPA science reassessment of causes and consequences of the hypoxic conditions in the Northern Gulf of Mexico suggest that nitrogen (N) and phosphorus (P) loads discharged from the Mississippi-Atchafalaya River Basin (MARB) are the primary cause of the Northern Gulf of Mexico hypoxic zone. Agricultural nonpoint source pollution is the main source of N and P in the Upper Mississippi River Basin (UMRB) and Ohio River Basin (OTRB) stream systems, primarily via nutrient inputs from fertilizer and/or livestock manure applied to cropland or pasture. The USEPA reassessment further pointed out that both N and P will need to be reduced by at least 45% each to achieve a target size of 5,000 km2 for the hypoxic zone and that the UMRB and the OTRB are the watersheds that contribute the greatest N and P fluxes to the Gulf. Specifically, these two basins contribute about 82% of the Nitrate-N, 69% of the total Kjehdahl nitrogen, and 58% of the total P fluxes to the Gulf despite representing only 31% of the total drainage area.

To address these issues, we are constructing the first fully integrated modeling system that will: (1) estimate nutrient loads from the UMRB and ORTB regions, in response to alternative cropping and/or management strategies, (2) then route the estimated nutrient loads for each scenario to the Gulf of Mexico, holding loadings from the other major tributaries (Missouri, Arkansas-Red-White, and Lower Mississippi) constant at baseline levels, and (3) input each set of nutrient loads into a hypoxic zone model to predict the impact on the size of the seasonal hypoxic zone. The Soil and Water Assessment Tool (SWAT) water quality model is being used to simulate the land management schemes in the URMB and ORTB and resultant nutrient loads, and will also be used for simulating the transport of the nutrient loads to the Gulf of Mexico. This SWAT application builds on previous national applications of SWAT within the Hydrologic Unit Modeling System of the U.S. (HUMUS) and National Conservation Effects Assessment Project (CEAP) modeling systems, as well as other previous applications for the UMRB. The placement of alternative cropping systems and/or management practices on specific

andscapes within SWAT for the two regions will be performed primarily via an interface with an evolutionary algorithm (EA) and corresponding cost data for each management system. Finally, a regression model is used to estimate the size the hypoxic zone, which has been developed using nutrient fluxes discharged from the Mississippi River, areal extent of the hypoxic zone, and other data collected that have been collected since 1985.

A description of the entire system will be presented, with emphasis on the development and application of the SWAT subcomponent of the modeling system. Results for selected preliminary scenarios will also be presented including estimated effects on the size of the hypoxic zone.

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Application of GIS-Based SWAT Water Management of Irrigation Project Under Rotational Water Supply

Sunil D. Gorantiwar

Abstract

Forecasts of water withdrawals on a global scale predict sharp increases in future demand to meet the needs of the urban, industrial and environmental sectors. India's efforts to increase food grain production have been achieved through promoting large-scale crop intensification by extending the area under irrigation. The expansion of irrigation has resulted in several undesirable consequences like low output from the stored water in the reservoirs and improper water distribution throughout the irrigation command. The objective of the present paper is to select the best compromise irrigation operation rule on the regional scale. This paper presents the developed framework tool using SWAT, GIS and irrigation model with a case study on Sina Medium Irrigation Project of Maharashtra State, India. A tool developed using hydrological model (SWAT) combined with GIS was used to simulate water movement and availability over a wide range crops, and soil conditions. The tool determines crop yield and profitability of irrigation project for the different combinations of operation rules on the regional scale. Once, developed, a decision support system or expert system can be applied to identify those regions of greatest need for irrigation, based on predicted increases in crop yield and profitability.

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Hydrological Modeling of Upper Godavari Basin Using SWAT Model

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Abstract

The distributed Soil and Water Assessment Tool – 2009 (SWAT – 2009) was applied to Upper Godavari River Basin for modeling its hydrological water balance under various river basin. The main objective of the study was to test the performance and capability of the SWAT model for prediction of the stream flow availability at the confluence of the Upper Godavari River with Manjra- one of the principal tributaries of the Godavari. For this study, the observed daily flow data available at Babli G&D site maintained by CWC has been considered along with land-use, DEM, soil, rainfall and weather data of the specific regions pertaining to the study area. The availability of river flow at the confluence of the Upper Godavari basin with Majira sub-basin of Godavari River Basin has been assessed under various simulation scenarios, namely with respect to (1) virgin flow condition (2) virgin flow and manmade interventions plus environmental flow requirement with respect to all existing major, medium and minor projects as at first stage of developments of the river basin without climate change effects consideration and (3) virgin flow and manmade interventions, environmental flow requirement considering existing major, medium and minor projects along with climate change effects (4) virgin flow and manmade interventions, environmental flow requirement considering all existing, ongoing & proposed major, medium and minor projects as at the ultimate levels of developments of the river basin and incorporating the effects of both environmental flow requirements and climate change impact conditions. In the processes, it is found that the model has the capabilities of simulating the supply and demand scenarios under various levels of developments of the Upper Godavari River Basin and can be applied to hydrological modeling for large scale applications at various River Basins /Sub-Basins Levels.

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Using SWAT-CUP to Consideration Rainfall Errors in a SWAT Application in Iran

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Abstract

Precipitation is the main driving force in hydrological modeling, however, precipitation data often contain missing values and the measurements are not error free. In conventional calibration techniques input errors (e.g. rainfall errors) are often not considered, hence leading to sub-optimum parameter sets. The objective of this paper is to investigate the effects of rainfall errors on hydrological models' outputs. For this purpose, Soil and Water Assessment tools (SWAT) model was used to simulate streamflow in six hydrometric stations in Hamadan-Bahar watershed, Iran. To evaluate the input uncertainty, Sequential Uncertainty Fitting, version 2 (SUFI2) algorithm in the SWAT-CUP software was used. Three scenarios of model calibration were examined in each station: 1) without any consideration of rainfall errors, 2) a correction factor is applied to all rainfall values, and 3) the correction factor is only applied to rainfalls corresponding to peak discharges. The results showed that the effects were different in each scenario in different stations. For example, in Yalfan station, scenario 3 demonstrated better results than the other two scenarios, in both calibration and validation phases. But, in Salehabad station, the result of scenario 1 was more acceptable. Comparison among scenarios indicated that introducing the correction factor for stations which underestimate discharge, especially the peak values, lead to more accurate simulation of peak flow rates. According to this research, to obtain more reliable parameters, it is recommended that rainfall uncertainty should be considered in hydrological models.

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Exploring Land Use Change with Combined Remote Sensing Techniques in the Upper Pennaiyar Catchment, South India

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Abstract

Land use has a major effect on water resources. Especially in monsoon driven environments, the water availability is temporarily limited and sustainable land and water management are necessary. Due to its rapid population growth, new cultivation techniques and climate change, India faces a dynamic change process. For sustainable water management valid high resolution land use data is required to gain process based knowledge of a dynamic environment. The upper Pennaiyar catchment (~5300 km²) is an intensively used agricultural area. The cultivation technique in the catchment is based on a traditional network of water storage ponds, which was constructed for irrigation farming. The study aims at detecting and analyzing modifications in land use and management over the last two decades. Multi-temporal remote sensing data of the Landsat (5 TM, 7 ETM+) and the IRS-P6 (LISS-III) satellites were used. Images from the early 1990s, near to the turn of the millenium and recent images have been analyzed by a combination of different approaches. Ground truth data, spectral measurements and knowledge based classification rules were combined to create high resolution (23-30 m) land use maps. The acquired high resolution data regarding land use and land management change is a valuable prerequisite to study hydrological change in this exemplary catchment in South India.

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GIS Framework to Evaluate Impact of Climate Change on Water Resources

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Abstract

Water resource management is of primary importance to the society, economy and the environment. Climate change is expected to have a significant impact on the hydrological cycle. Future greenhouse gas (GHG) emissions are the product of very complex dynamic systems, determined by driving forces such as demographic development, socio-economic development, and technological change. Scenarios are alternative images of how the future might unfold and are an appropriate tool with which to analyze how driving forces may influence future emission outcomes and to assess the associated uncertainties. These become the backbone of all climate change analysis, including climate modeling and the assessment of impacts, adaptation, and mitigation. The detection of these changes in hydrological phenomenon is complicated by conjoined effects of this variability over both short and longer term time scales, and by the effects of intervention of water resources projects at various scales.

The model set-up and runs were performed using SWAT hydrological model. SWAT model is a conceptual, distributed, continuous-time hydrological model that can simulate the water, sediment, nutrients and pesticides cycle. The GIS interface of this model ArcSWAT provides an excellent platform for data management and result analysis. The IPCC special report on emission scenarios (SRES) includes the range of emissions of all relevant species of greenhouse gases (GHGs) and their driving forces. HADRM3, a regional climate model (RCM) developed by the Hadley Centre for Climate Prediction, UK, has a resolution of 0.44°×0.44° and has been run for a range of SRES emissions scenarios. In the present study, two futuristic climate scenarios A2 and B2, and one baseline scenario BL has been used to address the uncertainty issues. Regional scale datasets used for model set-up were: land-use from Global Land Cover, soil from FAO and terrain model from SRTM. To induce a level of confidence in the generated results, the catchment was modeled using Indian Meteorological Department (IMD) gridded precipitation and temperature datasets. Generated model results are exported into Hydrologic Information System (HIS) database for further analysis.

The present paper describes a hydrological framework under development in the form of a Hydrologic Information System (HIS) which is intended to meet the specific information needs to assess the Climate Change Impact on Water Resources. The HIS incorporates hydrological model base to assess primarily various entities of water balance components, and flow at the sub catchment level for the various scenario. This framework would provide a common information base for the entire stakeholders to assess the impact of climate change for selecting appropriate adaptation strategies.

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Latest Advances of the BASHYT Framework: A Web, GIS Oriented, Interface for SWAT

Pierluigi Cau

Abstract

Several EU projects such as the EnviroGRIDS (http://www.envirogrids.net/) and CLIMB projects, funded within the FP VII Program, aim at building capacity for Catchment observation and assessment system supporting sustainable development. The ambition is to improve transnational cooperation, develop and apply innovative, state of the art web based technologies for analyzing states of the environment and share application and data. The BASHYT environment, a complex web interface for the SWAT model, is being further developed to meet user requirements and the challenges of these projects. We have set up a operational service open to the SWAT community, exposing visualization, analysis tools and web services for the SWAT hydrological model. The software is comprised of several client and server side software to import SWAT model I/O from the user desktop environment to the BASHYT server and to query, analyze, and navigate interactively on the WEB the result of any SWAT model run. In this last release several aspects have been improved with regards to the interoperability layer of the software. The BashytAPI exposes complex services to exploit the server side functionalities of the infrastructure. A preliminary e-learning application for BASHYT exploiting the BashytAPI has been developed using the EGLE environment. Also the GIS visualization has been deeply revised and improved mostly on the GIS query level. In this regards functionalities exposed on the web by BASHYT are very similar to those of the commercial ESRI ArcGIS desktop software.

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Development of an Open Source GIS based Soil-Water Assessment Tool for Small Land Holdings in a Semi-Arid Area

S. Vanitha, T. Karthick, K. Gandhiraj, S. Asiq Imran Khan, M. Jeevagan, N.V.N. Nampoothiri

Abstract

In Tamilnadu state of India, the land holdings are generally small for majority of farmers. Due to these small land holdings, it is difficult to implement optimal agricultural practices across these landholdings in a uniform manner. For implementing any uniform management practices, it is necessary to assess the present agricultural practices. In the present work, a GIS based analysis was done to assess the spatial variations of soil properties, water qualities, cropping pattern and yields of small land holdings in the village of Tambipatti in the Watrap Union of Sriviiliputtur Taluk in Tamilnadu. A socio-economic resource base was built over an open source GIS environment, "Quantum GIS". The GIS database development involved: collecting various socio-economic details of the farmers and analyzing the soil and water quality details, soil fertility status, the cropping patterns, management practices and the crop yields for these land holdings. It was found that the present agriculture and land management practices are not based on sound sustainability principles. Therefore it is proposed that an optimal soil and water analysis tool built around an open source GIS system is required to reach an optimal agriculture system for such collection of small land holdings.

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Assessment of Pesticide Application Date Shifts on Surface Water Contamination During Floods Using the SWAT Model in the Save Catchment (South-Western France)

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Abstract

In agricultural watersheds, pesticide contamination in surface water mostly occurs during flood events. Among all the parameters involved in the contaminations risks, the pesticide application date input was changed within a one-month interval using the Soil and Water Assessment Tool (SWAT) in an agricultural watershed in the South-West of France. The Save River drains an 1110 km² area of essentially wheat, corn, sorghum and sunflower grown with intensive pesticide inputs, mostly herbicides. The SWAT model was applied to simulate daily metolachlor and aclonifen transfer at the catchment outlet from January 2008 to June 2010. Metolachlor is a highly soluble and poorly lipophilic herbicide whereas aclonifen is a poorly soluble and highly lipophilic herbicide. A single catchment average application date established by a 3-year survey (2007-2009) was assumed for each land use. Total metolachlor concentration prediction could be improved by an application timing shift to 3 days later (Daily R^2 = 0.22 and PBIAS = -57%). Total aclonifen concentration prediction could not be improved by any timing shift in the chosen range of dates. By testing the behaviour of the two molecules, it was shown that sorption processes were driving the transfer. Metolachlor concentration in the channel mostly depended on both discharge and delay between application date and first flood event whereas transfer of aclonifen mostly depended on rainfall intensity for exportation with suspended sediments through surface runoff.

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Modeling Flow and Non-Point Contaminant Fate and Transport at a Catchment Scale in India

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Abstract

Excessive use of nitrogenous fertilizer vis-à-vis phosphatic and potassium fertilizers has resulted in a shift of NPK ratio from an optimal value of 4:2:1 to a distorted 7.9:2.9:1. Urea is the most common type of nitrate fertilizer used in India. Urea's hydrolysing property is high and hence is not retained by the soil. It gets leached to groundwater due to rainfall and irrigation water inputs and is thus distributed by the land phase of the hydrological cycle which requires knowledge of precipitation distribution, runoff generation, groundwater recharge distribution, and fertilizer application rate. Hence the distribution and fate of nitrates in surface and groundwater systems can be determined by integrating the analysis of the land phase of hydrological cycle with groundwater and hydrochemical analysis. This needs to be done on a basin-wide basis for large area applications. SWAT ArcView GIS version, a physically-based, time continuous model, has been used to simulate the land phase of the hydrological cycle, to obtain groundwater aquifer recharge and nitrate loadings in various components of runoff. The validation has been done for sub-basins of the Upper Yamuna catchment located in north of India. Results on surface runoff and groundwater levels obtained as outputs from SWAT simulation show a good comparison with the observed stream flow and groundwater levels using the Nash-Sutcliffe and R2 coefficient. Nitrate loading obtained after nitrification, denitrification, and nitrate removal from unsaturated and shallow aquifer zones were combined with deep groundwater recharge. This was followed by nitrate modeling in aquifers. Results of nitrate concentrations in deep groundwater aquifers obtained from MT3D were compared with observed nitrate concentration in aquifers and are found to be in good agreement. The fate of N was investigated in the Upper Yamuna catchment with an integrated approach the hydrological SWAT model coupled with the ground water model MODFLOW, and its companion contaminant and solute transport model MT3DMS.

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Management of the Trophic Status in Portuguese Reservoirs

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Abstract

The objective of the study was (1) to evaluate the trophic status in 29 Portuguese reservoirs, (2) to determine the TMDL for each of them and (3) to identify the catchment management policies that permit that TMDL. The first objective was assessed the criteria for evaluating the trophic level in reservoirs and compared the Carlson Trophic State Index (TSI) method with a method based on the OCDE criteria under discussion at Instituto da Água. The work showed that the trophic status should be evaluated using Chlorophyll-a and not using the Total Phosphorous. The connection between the reservoirs state and the watershed pressures (point sources, diffuse sources) were made using a watershed model (SWAT) and a reservoir model (CE-QUAL-W2) and the results were validated against field data.

The second objective to determine the TMDL was obtained using a biogeochemical model (CE-QUAL-W2) able to simulate the interdependence of the biological, chemical and physical interactions taking place in the eutrophic reservoirs. With the model validated for the reference scenario, load reduction scenarios were performed until the mesotrophic level was achieved. The input load that achieved a mesotrophic state was the TDML for that reservoir.

For the third objective the separation between point sources and diffuse sources impact in the reservoirs trophic state was addressed since the watershed management follows two different paths according to the origin of the source. This study has shown that in some catchments with the highest urban or animal occupation or with point sources near the reservoir (where summer urban loads can be an important part of the arriving load) were the main cause of the reservoir trophic status.

For other reservoirs, reductions of the diffuse loads were computed. Typical reductions on the order of 10 to 20% are expected to be enough for shifting the trophic level. In two reservoirs load reduction effort got higher than 40% and further work should include a finer identification of the diffuse origins (e.g. agriculture practices, animal production, soil loss, etc) and the quantification of their weight on trophic level to sustain future management strategies.

In reservoirs where input loads are low the reservoir geometry (usually with average depths lower than 10m) showed a factor that may consist an eutrophication risk. The continuous enrichment of the sediment (organic matter, nutrient) that occurs trough the years and the fact that light may arrive up to the sediments where nutrients usually are more available, creates a link to algal growth and eutrophication.

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Improving Modelling of Dissolved and Particulate Pesticides Transport in Rivers Using the SWAT Model in an Agricultural Catchment

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Abstract

The partition between dissolved phases and sorbed fractions onto suspended matters explains the dynamic of pesticides across the environmental compartments. In modelling approaches, the partition coefficient Kd is usually estimated from different empirical models linked to the octanol/water distribution coefficient Kow. We tested a new relationship for the partition coefficient Kd in rivers, relating Kd to Kow and to Total Suspended Matter (TSM). This relationship was obtained from the concentration measurements of TSM, of Particulate Organic Carbon (POC) and of 7 pesticide molecules (alachlor, atrazine, DEA, isoproturon, tebuconazole and trifluralin) at the outlet of the River Save. The latter river drains an 1110 km² agricultural watershed where intensive pesticide inputs are supplied each year, mostly herbicides. The relationship between Kd, Kow and TSM and its constants, suitable to the Save environmental context, were implemented in the Soil and Water Assessment Tool (SWAT) to improve pesticide fate modelling in this fluvial environment.

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Use of SWAT for Climate Change Impact and Vulnerability Assessment at District Level

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Abstract

A geographically disaggregated map of vulnerability to climate change is helpful for planning adaptation strategies. The IPCC working definition of vulnerability as a function of exposure, sensitivity, and adaptive capacity (IPCC, 2001) is used in this study as measure to calculate district level vulnerability to climate change. The index of vulnerability is composed of socioeconomic and environmental sub-indices. These sub-indices are in turn constructed as composite of various variables involved. Composite Socio-economic Vulnerability Index (CSEVI) is composed of sectoral vulnerability indices of Social (SVI) and Economic (ECVI) . Composite Environment Vulnerability Index (CENVI) is derived using indices on Climate (CVI), Water (WRVI), Agriculture (AGVI), and Forest (FOVI). This paper discusses Water Vulnerability Index (WRVI) generated at district level for the Madhya Pradesh state.

To start with, climate change impact on water resources was quantified using SWAT hydrological model with PRECIS simulated weather (IPCC SRES Control and A1B climate scenarios). GIS overlay analysis was performed to translate water related outputs from watershed to administrative boundaries. A composite spatial water vulnerability index of a district composed of four individual indicators namely water availability, crop water demand (Evapo-transpiration), drought weeks in monsoon months and flood discharge vulnerability. The indicators were assigned weights determined by Principal Component Analysis (PCA) to avoid the uncertainty of equal weighting. Districts were ranked based on the WRVI and cluster analysis was performed to group the districts into four vulnerability classes namely, very high, high, moderate and low according to their degree of vulnerability using Ward Method of Agglomeration.

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Variability in Normalized Difference Vegetation Index (NDVI) in Relation to South West Monsoon, Western Ghats, India

Dr. T.V. Lakshmi Kumar

Abstract

Eleven years (2000 to 2010) of Normalized Difference Vegetation Index (NDVI) data, derived from Moderate Imaging Spectroradiometer (MODIS) Terra with 250m resolution are used in the present study to discuss the changes in the trends of vegetal cover. The interannual variability of NDVI over western ghats (number of test sites are 17) showed increasing trend and the pronounced changes are resulted due to the monsoon variability in terms of its distribution (wide spread/fairly wide spread/scattered/isolated) and activity (vigorous/normal/weak) and are studied in detail. The NDVI progression is observed from June with a minimum value of 0.179 and yielded to maximum at 0.565 during September/October, on average. The study then relates the NDVI with the no of light, moderate and heavy rainfall events via statistical techniques such as correlation and regression to understand the connection in between the ground vegetation and the south west monsoon.

The results of the study inferred i) NDVI, Antecedent Precipitation Index (API) are in good agreement throughout the monsoon which is evidenced by correlation as well as by Morlett Wavelet Analysis, ii) NDVI maintained good correlation with no of Light Rainy and Moderate Rainy alternatively but not with no of Heavy Rainy days, iii) Relation of NDVI with Isolated, Scattered distributions and active monsoons is substantial and iv) Phenological stages captured the Rate of Green Up during the crop season over western ghats.

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Hydrological Modelling of a Semi-arid Basin Under Climate Change Scenarios

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Abstract

The fresh water availabilty of river basin in Southeast Asia has been decreased reasonably due to the climate change effect. Vaippar basin is one of the semi arid river basin in Tamil Nadu which faces water shortage nowadays due to climate variability and change. Since the variations in climate trends bring a notable change in the basin hydrology, this study focuses on impact of climate change in the water availability of the basin. This study uses the modelling techniques with the climate change scenarios which includes variations in precipitation and temperature. Analyses of future climate projections is done with the decrease of precipitation by 10% to 20% and temperature increase by 2.0° C will cause declining effect in the river discharge. This can be best handled by Soil & Water Assessment Tool (SWAT), and hence it is employed for the simulation of climate scenarios. Climate scenarios simulated with the SWAT model project consistent changes in future runoff and river discharge. These changes can be expected to have implications on water availability in the basin. The climate induced hydrologic changes in the basin is analysed by comparing the simulations between baseline (1970-2000) with the future time periods. Moreover, this approach facilitates the consideration of different climate-change scenarios and development of sustainable adaptation strategies for these scenarios in the basin. The distributed hydrological modeling that has the capability of generating the scenarios and presenting the simulation results for policy implications in the river basin. Keywords: climate change, climate change scenarios, baseline, SWAT model.

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Simulation of Erosion, Sediment Transport and Conservation Practices, using SWAT Model in the Gamasiab Watershed, Iran

Saeed Morid

Abstract

Sediment load estimation plays a crucial role in many water resources projects. In this research two different modeling paradigms, one using the common hydrological methods (i.e USBR, FAO, and etc) and the other SWAT (Soil and Water Assessment Tool) model were employed to estimate the amount of suspended sediment load in the Gamasiab watershed. The model was calibrated for both discharge and sediment concentration in three hydrometric station simultaneously. The sediment yield calculated by SWAT was 2.8 ton/ha, which was much closer to observed values (2ton/ha) than the results produced by the USBR method (4.9 ton/ha). Furthermore, various conservation measures were investigated using the calibrated model. Results indicated that constructing check dam at the upstream of the erosion-prone sub-basins, could reduced annual sediment yield by 16%. Adopting a combination of conservation practices such as constructing check dam, stripe cropping in irrigation farmlands and contour cropping or alternation in rain-fed farmlands would reduce the annual sediment load by 35%.

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Water Footprint Analysis of Biofuel Feedstock Using SWAT Model

Pushpa Tuppad, R. Srinivasan, Debjani Deb

Abstract:

Water use and water availability is region specific and essentially linked to the hydrology of the region. Understanding water variability and water accounting through watershed or a river basin scale approach has been adopted increasingly lately. The overall goal of this study is to assess the potential water availability and water quality impacts of various biofuel feedstock production alternatives in Upper Mississippi River Basin (UMRB), USA using the Soil and Water Assessment Tool (SWAT) model. Firstly, a link of relevant SWAT-model outputs to the water footprint (WF) terminologies at the river basin scale is developed. The WF methodology looks at blue, green and grey water from an agriculture or production facility. The model is calibrated and validated at the monthly scale. The WF components are assessed for UMRB from the calibrated model. Different scenarios modeled include continuous corn cropping scenario with different stover removal rates and the scenarios of gradual spatial conversion of the current cropland to switchgrass.

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GIS Based Distributed Modelling of Soil Erosion and Sediment Yield for Isolated Storm Events- A Validation Study of Dream

Raaj Ramsankaran

Abstract

This article presents a validation study conducted for a GIS based process oriented physically based distributed (PBD) hydrological model called Distributed Runoff and Erosion Assessment Model (DREAM) in the semi-forested watershed of Pathri Rao, located in Garhwal Himalayas, India. DREAM is capable of handling watershed heterogeneity in terms of landuse, soil type, topography, rainfall, etc. and generates runoff and sediment yield estimates in spatial and temporal domains. Unlike other PBD models, all the inputs of DREAM can be measured in field. The proposed model is based on simultaneous solution of flow dynamics followed by soil erosion dynamics. The flow dynamics is based on the well accepted kinematic wave theory. As the storm rainfall proceeds, the process of generation of overland depth is a dependent function of interception storage and infiltration rates. These have been taken care of by the use of modified Merriam (1960) and Smith & Parlange (1978) infiltration approaches. The components of the soil erosion model have been modified for better prediction of sediment flow rates and sediment yields (Ramsankaran 2010). The model validation study conducted to test its predictive ability and performance in simulating soil erosion and sediment yield during different storm events registered in the study watershed shows the model results are satisfactory. It is noteworthy to mention here that the distributed nature of the model combined with the use of Geographical Information System (GIS) techniques allows computation and presentation of spatial distribution of sediment yield for the simulated storm events. Hence to highlight the capability of the develop model, such spatial distribution map for one of the simulated storm events is also presented in this article.

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Attempt to Application of SWAT Model in Lack of Exact Data Situation in Southern Poland

Maria Smietanka

Abstract

One of the aims of the project, financed by European Space Agency in the Plan for European Cooperating States, is to support the management of water bodies by integrating Earth Observation derived land cover / land use information and other easy accessible data into SWAT model. Project is conducted on Ropa catchment in southern Poland. It is a piedmont area, covered partially with forests and with intensive agriculture on the remaining part. Model inputs were maps as well as remote sensing data. There was a problem with a lack of data from the exact catchment. There was an attempt made to use SWAT with possibly free or cheap data available in Poland to show the opportunities of modeling also in other part of the country. The main problem was meteorological data, which in Poland are very expensive. Calibration was made with free data from outside the catchment, to see weather it is possible to use this kind of data. It has a great influence on results (some water rising are missing, some are overestimated), but thus we get a NS coefficient 0,63 for daily flow. Also nitrogen was calibrated, and the model shows tendency in appropriate way, even without precise land use maps on the exact plant level. This can be a proof for water management organizations in Poland, that also in the situation with lack of data or difficult availability they can use models and get reliable results.

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Calibration of SWAT Model for Small Agricultural Catchment in Poland - Problems and Results

Smarzynska Karolina, Miatkowski Zygmunt

Abstract

One of the Nitrate Vulnerable Zones designated in 2004 in Poland, according to the Nitrate Directive of EU, is upper Zglowiaczka river catchment, one of the most intensive agriculturally used areas in Poland. The objective of the application of SWAT into that catchment is to use a model as a tool for catchment management considering water resources management and water quality at rural areas.

As the water is the driving force of nutrient transport in the catchment, the careful hydrologic calibration of SWAT model need to be done, before the calibration of nitrates load. The aim of the study presented in the paper is to describe the state of advance in application of SWAT model to intensively agriculturally used pilot catchment in central part of Poland considering hydrologic calibration of the model in connection with sensitivity analysis. Sensitivity analysis is highly recommended as a first step in model calibration process especially for the catchments with luck of long-term measurements of discharge (as it is for upper Zglowiaczka catchment). The results of the sensitivity analysis indicated that parameters controlling the amount of evapotranspiration (EPCO, ESCO, CANMX) are the most sensitive ones. Considering the fact that evapotranspiration amounts around 90% in the water cycle within the catchment, such high ranks of those parameters are reasonable. At the moment of the study the Nash-Sutcliffe Efficiency for monthly discharge for 4-years of calibration is 0.78 and R2 is 0.79, whereas for daily discharge it is 0.47 and 0.47 respectively.

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Impact of Climate and Landuse Change on the Hydrology and Water Quality of Major River Basins in the US

Debjani Deb

Abstract

As part of the U.S. EPA's Global Change Research Program (GCRP) the Soil and Water Assessment Tool (SWAT) was used to model 7 large river basins in the US. The aim of this work was to enhance our knowledge of the potential sensitivity of U.S. streamflow and water quality (nutrient and sediment loading) to both climate and landuse change across a broad range of mid-21st Century climate futures. This work describes the overall structure i.e. integrating climate models, land-use models and watershed models and discusses the results generated for the watersheds across varied geographic regions. Specifically, we evaluate modeling results that illustrates procedural issues, sensitivities, and uncertainties associated with carrying out these types of climate/landuse change-hydrologic impacts assessments, including: the sensitivity of simulated changes to climate model and downscaling approach used; and the interaction between climate change and other forcing factors, such as urbanization and change in atmospheric CO2 concentration. In addition, the results will also provide an overview of the response to climate change in different geographic regions and the different sensitivities of an array of flow and water quality endpoints.

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Rainfall Runoff variability over Semi-urban Catchment, Maharashtra, India

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Abstract

Long-term rainfall and associated runoff characteristics are good indicators of catchment response over time. Present study is being carried out for the upper Bhima catchment, a part of Krishna basin, India, and receives an average annual rainfall of about 1140 mm. Its landscape has been changing continuously due to various anthropogenic activities, which is more rapid in recent times. Keeping this view in background the rainfall runoff data since last two decades (1985-2004) were analysed to find out whether any alteration in these phenomena has occurred significantly. Moreover, availability of daily rainfall and stream flow records from 16 rain gauge and 10 river gauge stations in the catchment gives an opportunity to study such anthropogenic effects. Linear Regression and Mann-Kendall (MK) tests were applied for studying temporal rainfall trend in the area, along with the runoff trend observed near outlet. Inter-annual variability and decadal rainfall pattern was studied statistically; whereas the spatial pattern of rainfall was analyzed through geo-spatial interpolation technique. The study period was divided into two decades i.e. D1 (from year 1985 to 1994) and D2 (from year 1995 to 2004) to analyze rainfall-runoff process. The Study revealed that overall rainfall pattern in the area was nearly constant, whereas a significant decline rate (-1285m3/s per year) of stream flow was observed during study period. The mean annual rainfall during period D1 and D2 was about 1213mm and 1148 mm respectively, where as runoff was almost doubled during period D1 with respect to D2. Growing agricultural activities supported by construction of reservoirs, increasing demand of domestic and industrial water in upstream areas are main factors behind runoff alteration during the study period.

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Impact of Climate Change on Catchment Hydrology and Rainfall-runoff Correlations for Karajan Reservoir Basin, Gujarat, India

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Abstract

Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer).Global and regional climate has been changing as evidenced by temperature increase, increase in rainfall intensity etc. The impacts of climate change primarily driven by global warming are highly extensive, complicated, and uncertain. Availability and variability of water resources will be affected by climate change effect. The impacts of climate change on water resources have received much attention globally especially in the last 30 years. Rainfall, the main driver of the hydrological cycle, has been varying in parts of the world. In this view, regionalizing the hydrologic response under a changing climate is a need of an hour for the better Water Resources Management of the basin.

To regionalize the hydrologic response under a changing climate, the field of study has been chosen as "Impact of climate change on catchment hydrology and rainfall- runoff correlations for Karajan reservoir basin, Gujarat, India." The objectives of this study are: i) to assess the evidence of change in the climate, ii) to assess the impact of changing climate on catchment hydrology iii) to evolve the Rainfall – Runoff model under the changing climate

Analyzing the available meteorological data from year 1961, it is found that the climate has shown significant changes from year 2000 in the region. The impact of changing climate have been studied on the catchment hydrology and rainfall-runoff model have been established under climate change scenario and have been compared for reference scenario.

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Watershed-level Comparison of Predictability and Sensitivity of Two Phosphorus Models

Sumit Sen

Abstract

Buildup of phosphorus (P) in agricultural soils and transport of P to nearby surface waters due to excessive, long term application of poultry litter is a major environmental concern in many poultry producing states. Watershed models are often used to quantify soil and water quality impacts of poultry litter applications. However, depending on how P transport is simulated in the models, the anticipated impact could be quite different. Therefore, the objective of this study was to determine the sensitivity of two P models (Soil and Water Assessment Tool (SWAT) P model and a newly-developed state-of-the-art manure P model called SurPhos) from a poultry litter-applied pasture watershed. A small, predominately agriculture watershed in Randolph County, AL was used for this study. The SWAT model was calibrated with 2004 and 2005 flow data with Nash-Sutcliffe coefficient of 0.70 for both surface runoff and total streamflow. Dissolved P simulated by SWAT P and SurPhos models from hay hydrological response units (HRUs) of the watershed were compared for different poultry litter application rates. Both models showed sensitivity to application rates. SWAT model simulated an average increase of 0.21 and 0.48 kg/ha/yr of total dissolved P (TDP) export for every 1121 kg/ha increase in application rate at initial soil labile P (SLP) levels of 0.50 mg/kg, and above 5 mg/kg, respectively. However, the SurPhos model simulated an average increase of 0.42 and 0.52 kg/ha/yr at different initial SLP levels. Simulation scenarios suggest that SWAT over-estimates TDP exports from higher SLP fields. On the contrary, SurPhos model appropriately identifies manure P as the main source of dissolved P in runoff. Also, SWAT suggests faster buildup of soil solution P in the top 1 cm as compared to the SurPhos model. Since SurPhos model appears to simulate P transport processes from manure applied areas more accurately, the study suggests that the SWAT P model be replaced by the SurPhos model to more accurately determine watershed-level effectiveness of P management measures.

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Hydrodynamic Modelling of Vembanad Lake

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Abstract

Wetlands, estuaries and other aquatic systems, all over the world, are facing situations of extreme stress on account of anthropogenic interventions fuelled by aspirations for a diverse set of services that these water bodies are believed to have the capacity to provide. Vembanad wetland system of Kerala, India, is a designated Ramsar site of international importance and has understandably witnessed an ever increasing but diverse set of demands for its limited resources. Besides the conflicting demands of fresh water agriculture and the long standing tradition of estuarine pisciculture, tourism is also a major industry supported by the Vembanad system. The Vembanad Lake has also witnessed engineering interventions such as (i) construction of Thottapally spillway in the south as a flood control measure in the Kuttanad area, (ii) Thanneermukkam Barrage as measure to control lake salinity and other tidal influences and (iii) periphery bunding as a demarcation of paddy areas from rest of the lake area.

Lake management strategies, implemented mainly through active control and operation of Thanneermukkam barrage and a passive control on account of uncontrolled diversion of water to the sea via Thottapally spillway, are required to manage lake water quality according to prescribed rules that seek to restrict lake salinity to a maximum of 2.0 ppt. In addition to perceived tidal influences as a factor controlling lake salinity, Vembanad Lake also receives a heavy discharge of industrial effluents that further exacerbate the lake water quality.

The present study tries to find the impacts of the various water resources development plans on the Lake water quality through hydrodynamic modeling that seeks to evaluate the likely spatial and temporal changes in pollution concentration as a result of these plans. The study has been carried out using the 2-dimensional hydrodynamic modeling software MIKE 21 with HD and AD modules. The results, although not representative, show that any further water resources development may prove detrimental to the ecology of the lake.

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Estimation of Spatially Enhanced Wavelet Based Evapotranspiration Using Energy Balance Approach

Gowri Senthil Kumar

Abstract

Evapotranspiration (ET) is one of the major components of the hydrologic cycle which links the water cycle and energy balance together. Conventional techniques that are based on the point measurements are representative only at local scales. The problem of actual ET estimation over a large area can be solved using remote sensing methods that provide ET on pixel-by-pixel basis. The objective of this paper is to estimate spatial distribution of actual ET from satellite remote sensing images at high spatial resolution. This study has been carried out using Landsat 7 Enhanced Thematic Mapper + sensor. The Surface Energy Balance Algorithm for ¬¬Land (SEBAL) was used to estimate actual ET. The Thermal Infrared (TIR) remote sensing data is very essential in the estimation of the actual ET. The spatial resolution of the resulting ET maps is determined by the pixel resolution of the TIR sensor. Data fusion techniques take advantage of the complementary spatial/spectral resolution characteristics of imaging sensors to spatially enhance the acquired image. The fusion scheme should preserve the spectral characteristics of the original low resolution TIR imge. Hence to satisfy this criterion the Multi Resolution Analysis (MRA) technique based data fusion was used in this study. The Discrete Wavelet Transforms (DWT) was adopted in this research work to spatially enhance the TIR image. The ET information is estimated using this spatially enhanced TIR images. Further the distributed values of actual evapotranspiration obtained from the developed methodology could be utilized directly in the hydrological and crop models for addressing various hydrological and agricultural problems

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Assessment of Groundwater Resources and Quality in Bist Doab Region, Punjab, India

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Abstract

The long term groundwater level trend indicates increasing groundwater stress in Bist-Doab region of Punjab with maximum stress in central zone of the region and in central part of piedmont zone (locally known as Kandi). The rate of decline in groundwater is as much as 0.9m/year in some locations of the region whereas, favored hydrogeology and relatively low use of groundwater has led to moderate to high groundwater potential along the flood plains of the rivers Satluj and Beas. Depletion of groundwater has resulted mainly due to increase in irrigation demand, domestic requirement and reduction in surface water-bodies. These have resulted in highest groundwater abstraction per unit area in Jalandhar followed by Kapurthala district. In some parts of Kandi region, groundwater utilization is less mainly due to hilly terrain and occurrence of groundwater at levels exceeding 100m bgl. The net groundwater availability in Bist-Doab region is 333,656ha-m, which is much smaller than the total groundwater draft of which the draft for irrigation itself constitutes 571,549ha-m. Except hard terrain zone, which is thinly populated, almost entire Bist Doab region comes under dark category with groundwater utilization exceeding 300%. Regionally, groundwater quality is fairly good except at few locations showing salinity, hardness, heavy metals, fluoride and sulfate concentrations above the safe drinking limit. Various measures can be adopted to improve groundwater resource, which include augmentation of groundwater resource through artificial recharge measures, conjunctive use of surface water and groundwater system, use of blending technique in irrigation practices in areas where groundwater quality is poor. The present paper provides a comprehensive account of stage of water resources in Beas-Satluj Doab region.

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Abstract

The SWAT (Soil and Water Assessment Tool) model was used to estimate terrestrial sediment and nutrients loads to Galveston and Matagorda bays from their contributing watersheds. In this report, the term "terrestrial loads" represents the sum of gauged loads from gauged subbasins and model-generated loads from ungauged subbasins. Municipal WWTPs and industrial point source discharges are not included in this calculation of water quality variables. This information, however, would be required to calculate the total nutrient load actually reaching a bay. Due to the lack of information of sedimentation and contributed nutrient load from the watersheds it was impossible to compare the SWAT outputs with estimated loads from literatures.

In this study, two watersheds, Galveston Bay and Matagorda Bay, were selected for a pilot study because one represents an urbanized watershed (Galveston Bay) and the other a rural watershed (Matagorda Bay). The project consists of two parts. Hydrologic simulation was performed in the first phase, and the second phase focuses on the estimation of sediment and nutrient loads. We used the USGS LOAD ESTimator (LOADEST) program to extrapolate the water quality samples into monthly data. Modeled monthly sediment showed very good agreement when compared with observed TSS with R2 ranging from 0.76 to 0.93 and NSE ranging from 0.70 to 0.93. Estimated monthly total nitrogen and total phosphorus showed good to acceptable correlation with observed values with R2 ranging from 0.69 to 0.80 and NSE ranging from 0.49 to 0.79, while predicted monthly nitrate was not satisfactory.

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Effect of Irrigation on Soil and Ground Water in the Ukai Right Bank Command Area (District Surat)

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Abstract

Irrigation has contributed immensely to the Indian agriculture by making the nation food surplus. However, the irrigation is not an unmixed blessing. In spite of various precautionary measures it has brought problems of waterlogging and soil salinity / Alkalinity. With a view to realise optimum benefit from irrigation, it would be desirable to reclaim the affected lands and to take steps that would curtail further development of these problem to the minimum level. Soil salinity problems in irrigated command develop whenever soil and hydrological conditions favour the accumulation of soluble salts in the root zone. The rise in water table in irrigated command areas mobilises the salts presents in the soil profile and ground water. Once the ground water table rises within 1.5 m and / or upto 3.0 m of the soil surface, it contributes sustainability to evaporation from the soil surface and water uptake by plants. The upward flux of water due to evaporation and water uptake by plants, results in gradual concentration of salts in the root zone. At this stage, mostly information available from secondary sources augmented by selective sampling and analysis is used to diagnose the problem. However field investigations, soil and water sampling procedures and important laboratory investigations are needed to exactly diagnose the problem. In this paper the discussion of soil and ground water table and its quality of the Ukai Right Bank command Area (Dist. Surat, Gujarat) is presented.

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Estimating the Effects of Agricultural Conservation Practices on Water Quality in the Mississippi River Basin

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Abstract

Increased use of conservation practices in agriculture in the United States has reduced the field losses of sediment, nutrients and pesticides to rivers, streams and other water bodies. Although several studies exist that estimate the effects of conservation practices on soil and water quality at field scale and watershed scale, comprehensive efforts to quantify the effects of the conservation practices at regional/national scale are limited. Hence, an analytical approach involving modeling and farmer surveys was developed to quantify the environmental benefits of conservation practices on cropland as part of the USDA's - Conservation Effects Assessment Project (CEAP) national assessment. The modeling approach uses a farm-scale model, Agricultural Policy Environmental Extender (APEX), and a watershed scale model, Soil and Water Assessment Tool (SWAT), with GIS databases on land use, soils, land use management, topography, weather, point sources and atmospheric depositions to derive model inputs. APEX is used to simulate conservation practices on cultivated cropland and Conservation Reserve Program land based on management data derived from farmer surveys. Flow and constituent loading from APEX are input into SWAT and SWAT simulates the non-cultivated land including pasture, range, forest, wetland and urban lands and deposition of atmospheric nitrogen on the land. SWAT then routes flow and pollutants generated from non-cultivated land and point sources along with APEX loadings from cultivated land through 8-digit watersheds (approximately 3,000 km2). The system is calibrated at 8-digit watersheds and at selected gauging stations for flow, sediment, nutrients and pesticides. This study provides a brief overview of the modeling approach used and the effects of conservation practices on water quality in the Mississippi River Basin (MRB). The paper also examines the effects of agricultural conservation scenarios on water quality conditions of the entire MRB under current conservation and alternative conservation conditions and provides insights for addressing the hypoxia issue in the Gulf of Mexico.

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Application of SWAT Model to Predict the Impact of Alternative Cropping Pattern and Irrigation Efficiency on Water Productivity: A Case Study on Zarrine Rud River Basin, Iran

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Abstract

Improving performance of irrigation systems in arid and semi-arid regions due to limited water resources is of great importance. The concept of Water Productivity (CWP) is suitable indicator that makes it possible to evaluate different agricultural management measures in an integrated prospective. In this study, the aforementioned indicator is evaluated with respect to alteration in cropping pattern and irrigation efficiency in Zarrine Rud Basin using Soil and Water Assessment Tools(SWAT). The calibration of the model was done by SWAT-CUP and the record of 1987 to 2005 of 7 river discharge stations. The calibrated model was then applied to evaluate the effects of cropping pattern as well as irrigation management strategies on CWP. The results showed that changeincropping pattern has improved CWP from 1.75 to 2.81. While increasing irrigation efficiency by mobilization of the system has enhanced the indicator from 1.75 to 2.14. Notably, the second strategy has negative impact on ground water storages of the basin.

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Crop Production in a Changing Climate of Krishna River Basin

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Abstract

In this complex world of changing climate there is a vital need to, better manage surface and ground water resources. As the demand for water from all the sectors is ever increasing there is an urgent need for comprehensive assessment of available water resources. To accomplish this, it is necessary to understand the role of interrelationships between the various complex factors such as climate, soil, landuse, slope, surface water and ground water etc. ArcSWAT hydrologic modelling tool does exactly the same to incorporate each of these factors and their inter-relationships.

In the Krishna River Basin, one of the longest rivers in south-central India. The total cultivable area in the basin is 77 % of the total geographical area of the basin, a vast amount of which is under irrigation. Climate change will have a direct impact on, water availability, water requirement and crop yields in the basin. GCM simulations downscaled to 0.25° × 0.25° using the regional climate model IPRC-RegCM was used to simulate the climate change impact on the basins using SWAT. Prelimnary analysis show that flooding in the basin would be a major concern. Further work in ongoing to simulate the effect of alternate crop/water management practices to mitigate the climate change impact.

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Assessment of Climate Change Impacts on Environmental Flow Release from a Multi-purpose Dam of South Korea Using SWAT Modeling

Rim Ha

Abstract

This study is to evaluate the climate change impact on future environmental flow secured in a dam. For the purpose, the Soil Water Assessment Tool (SWAT) was adopted and it was prepared for a watershed including a multi-purpose dam. The model was tested using multi-sites observed data of upstream and downstream including dam release data. For future evaluation, the MIROC3.2 hires A1B and B1 scenarios were applied. After bias correction using the ground measured data, the climate data were temporally downscaled using LARS-WG method. For the 2040s and 2080s, the availability of environmental flows will be checked at first and briefly discuss the adaptation strategies by looking at the temporal variations of future dam inflow and water level management for proper water supply.

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Effects of Extreme Climatic Events on Water Availability and Quality

Somsubhra Chattopadhyay

Abstract

Global climate change is expected to increase the probability of extreme events in the future. Higher water temperatures, increased precipitation intensity, and longer periods of low flows are projected to exacerbate many forms of water pollution, including sediments and nutrients, affecting human health, ecosystems, and water use. This study will focus on evaluating water availability issues for the Jordan Lake in North Carolina under various extreme climatic conditions as influenced by the potential climate change. The specific objectives are (1) develop various methods of representing extreme climatic events for hydrological impact studies, (2) quantify basic inter-relationships of hydrologic response and climate extremes through watershed modeling approach, and (3) quantify the relationship of scaling small scale effects to regional scale impacts of water availability due to extreme events.

This study will employ the Soil and Water Assessment Tool (SWAT) model to examine the hydrological response of Haw River Basin, the largest tributary of the Jordan Lake, using various software, user interfaces, and input databases of topography, land use, soil, land management, and climate. The modeling framework will be coupled with the climate models recommended in the IPCC Climate Change Assessment report. The modelling framework is being built with GIS data layers on topography, landuse and soil charecteristics, historical climate observations at various weather stations within the watershed, database on point sources and various software.

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Hydrological Modelling of Cauvery River Basin to Assess the Sustainability of Irrigated Agriculture due to Climate Change

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Abstract

Studies have well established that climate change will have adverse impacts on agriculture and water resources, especially in developing countries like India. Given the large proportion of the population dependent on agriculture – directly and indirectly – adverse effects on agriculture could easily translate into an escalation of poverty. Coping with the impact of climate change on agriculture will require careful understanding of the interrelationship between various natural elements like soil, climate, terrain parameters and cropping practices. To understand this complex interrelationships, a continuous physical based hydrology model Soil and Water Assessment Tool (SWAT) model, was used in the present study to assess the impacts of climate change on hydrology and cropping system in Cauvery basin. Cauvery basin is one of the major river basins of the Peninsular India, which covers cultivated area of 38,954 km2. Change in climate has strong influence on hydrological parameters and crop growth in Cauvery basin. GCM simulations downscaled to 0.25° × 0.25° using the regional climate model IPRC-RegCM was used to simulate the climate change impact on the basins using SWAT. Preliminary assessment of the model result revealed that more attention should be given to the irrigation management practices. Future studies will be focus on the response of the basin to different irrigation and cropping patterns to mitigate the impacts of climate change.

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A Tool to Analyze and Present Large Volume of Model Outputs: Ganga Basin SWAT Modeling Case Study

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Abstract

The study presents the results generated for assessing implications of future water resource developments in the Ganga Basin on water quantity and quality using hydrological model SWAT. The study has been commissioned by the World Bank.

Analyses were performed to evaluate the change in sediment yield on account of the changes in the precipitation intensity under climate change scenarios and by incorporating the developmental and population increase in the basin. There is a general trend of increase in sediment load in future due to the increase in intensity and magnitude of rainfall towards mid century. BOD loads have been computed using population of the cities and used as point loads in the SWAT model to simulate the quality of flows. The analysis show that, average annual BOD concentration fared well, however seasonally only during monsoon period the water quality is of acceptable level. During non-monsoon season the entire river reaches reveal poor water quality and BOD exceed the international acceptable level of 3 ppm.

The study has generated very large outputs that not only cover a large range of spatial units but also a range of temporal scales. It was not possible to present these outputs and findings to a diverse cross-section of stakeholders through a single report. Therefore a standalone GIS based framework has been formulated to help users to interactively explore the Ganga system in terms of various features along with the SWAT outputs for implications of development and climate change at various levels of details.

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Development of Soil and Landuse Map for Hydrological Modelling Purposes Using SWAT

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Abstract

The Government of India has declared River Ganga as a "National River" and constituted an authority (National Ganga River Basin Authority – NGRBA) to regulate the activities in the river basin. GoI in consultation with NGRBA has setup a consortia of seven IIT's to develop a comprehensive management plan to clean river Ganga. For developing such a management plan, a detailed landuse and soil data is very important. The Soil survey maps available from National Bureau of Soil Survey and Landuse Planning (NBSSLUP) has a resolution of 1:500,000. However, these maps only provide information on soil taxonomy class, but does not contain the soil textural and hydraulic properties for different soil layers. Hence, the soil textural properties were inferred by matching with soil pedons having similar soil taxonomy, from among the thousands of soil pedons contained in the "ISRIC-WISE Harmonized Global Soil Profile Dataset" and "USDA NRCS soil pedon database". Pedo-tranfer functions developed by Saxton and Rawls (2006) were used to estimate the other soil hydraulic properties. The landuse data for the entire Ganga basin was developed by merging data from two different landcover maps from National Remote Sensing Centre (NRSC) and Global Irrigated Area Map (GIAM). The comprehensive soil and landuse data developed from this study will help in studying the hydrology of the basin using SWAT for developing an effective river basin management plan.

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Agricultural Water Demand Modeling Using HEC HMS Soil Moisture Accounting for Ajay River Basin, India

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Abstract

Agricultural demand, particularly for irrigation water, which is a major share of total water demand of India, is considered more sensitive to climate change. This paper quantifies the impact of climate change on the water resources of the Ajay river catchment outlet at Jamtara, using a distributed hydrological model HEC – HMS after due calibration using historical data and GIS coupled with RS. The study uses the HadRm daily weather data to determine the control (present) and GHG (future) water availability in space and time.

A total of 15 years of simulation spanning the entire Ajay river catchment has been conducted. Five years were devoted to control (present) 1997 – 2001 and the remaining 10 years (2040 – 2050) devoted to GHG (future) climate scenario.

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Hydrological Modelling of the Upper Ganga Catchment Using SWAT Model

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Abstract

Ganga is a rain, snow and glacier fed perennial river which originates in the Western Himalayan Mountains. The flow of this river is highly seasonal. The high flows caused by the monsoon rains are responsible for frequent floods and the low flows in the winters cause difficulties in meeting the irrigation and other demands. River water can also be used to generate hydropower in head reaches where slopes are steep. Hydro-infrastructure needs to be constructed and operated optimally to overcome problems due to high seasonality of flows. The hydrological modelling of the basin is being taken up as a part of the Ganga River Basin Management Plan (GRBMP) initiated by the Government of India with the combined efforts of 7 IITs.

This paper describes the results of modelling of the Upper Ganga catchment which covers about 85,000 sq. km area and has immense variations in topography, geology, soils and vegetation types. The SWAT model is being employed for: 1) hydrologic modelling of the Ganga basin and 2) studying the impacts of climate and land use/cover changes on water resources of the basin. For modelling purposes, the Upper Ganga catchment has been divided into 15 sub basins. The data used here includes the DEM, land use and soil properties acquired from different sources. Apart from these, weather data, discharge data, and other required data were acquired from the India Meteorological Department, Central Water Commission, etc. The land use in the area was classified into about 25 land use classes and the soil types were divided broadly into about 12 classes. The model was set-up using these data. Calibration of the model is being done by using the measured discharge data for the period 1971-75 and 1981-85 (data are available in time slices of 5 years) and data for 2000-05 will be used for validation. Initial results suggest that the model is performing well; fine-tuning of parameters is currently in progress. The paper will describe the results of modelling.

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Hydrologic Modelling of the Eastern Contributing Basins of Vembanad Lake Using SWAT

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Abstract

Modelling plays a very important role in arriving at the diagnosis of past behaviour as well as a prognosis of the likely future states of a given basin's hydrology. It is indeed important to objectively evaluate impacts of past or proposed anthropogenic intervention on the natural system's hydrologic and/or hydraulic responses. In this study rainfall runoff models have been developed for the five principal contributing river basins of the Vembanad Wetland System in the state of Kerala in India and further, within this derived hydrologic framework, the likely future impacts of various water resources development initiatives have also been assessed.

Flow from the five rivers namely Muvattupuzha, Meenachil, Manimala, Pamba and Achenkovil debouch into the southern part of the lake system. Hydrologic models, duly calibrated and validated using available record of observations, were developed for these latter systems using ArcSWAT. Simulations were performed for the presently existing development scenario as well as the likely future scenario by incorporating all known developmental proposals in addition to the proposal that entails a trans-basin-boundary export to the Vaippar basin in the neighbouring state of Tamil Nadu. The impact on the flow in terms of percentage reduction was found to be greater during non-monsoon season when the rainfall is relatively meagre thus rendering the system more vulnerable to possible degradation of the riverine and the connected lake environments.

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Evaluation of ArcSWAT Model for Streamflow and Sediment Yield Simulation in a Subhumid Hilly Watershed of Eastern India

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Abstract

Recently, GIS-based watershed models have become vital tool for watershed research, planning and management. In the present study, ArcSWAT model was used to simulate daily streamflow and sediment yield from Baitarni watershed having 1776 Km2 area in upper Baitarni river basin of eastern India. Digital Elevation Model of 30m resolution, classified land use/land cover map, soil map and daily climatic data were used for model development. Shuffled Complex Evolution Algorithm (SCEA) optimization technique was used for calibration of model using 5 years (1999-2003) of daily streamflow and two years (2002-2003) of daily sediment yield data keeping 1998 as warming up period. Validation of model was done with two years (2004-2005) of daily streamflow and sediment yield data. The statistical evaluation results for streamflow simulation during model calibration and validation at daily and monthly time steps showed that the values of Percent bias (PBIAS), RMSE-Standard deviation ratio (RSR), Nash-Sutcliffe efficiency (NSE), and Coefficient of determination (R2) vary from -1.94 to 1.14, 0.24 to 0.39, 0.84 to 0.95, and 0.86 to 0.96 respectively. For sediment yield simulation at daily and monthly time steps, the values of PBIAS, RSR, NSE, and R2 were found to range between -5.65 to 5.75, 0.28 to 0.61, 0.59 to 0.91, and 0.62 to 0.92 respectively. Further, a visual checking of hydrographs and scattered plots indicated a good agreement between observed and simulated streamflow and sediment yield data. The good performance of ArcSWAT model during calibration and validation suggests that this model can be used as an effective tool for the watershed management in the Upper Baitarni River Basin.

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Application of SWAT Model for Water Resources Management in Kopili River Basin in NE India

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Abstract

Accurate estimation of water availability on spatial and temporal scale is prerequisite to water resource management. With the advances in hydrological models supported by GIS tools and remote sensing data, the constraints related to inaccessibility for assessment of water resources have significantly reduced in recent past. In the present study a semi distributed process oriented SWAT model was applied to Umkhen watershed of Kopili River basin in India to assess the spatial and temporal variation of water resources. The data requirements of SWAT model for this typical hilly watershed were fulfilled from locally available sources. The climatic data of Umkhen was taken from two well established meteorological stations. Similarly, the observed discharge data was taken from a gauging station located at the outlet of Umkhen. The data was available for the period of 1988-1993 and was used after testing the non-significant differences with the long time data pertaining to the study region. The sensitivity analysis indicated curve number as the most sensitive parameter affecting the hydrology of Umkhen watershed. The prediction performance of the model was assessed through multi-stage validation process. This was done to ensure the applicability of the model with minimum prediction error. As a validation procedure, observed and simulated water yield at the outlet were compared with satisfactory level of agreement. Coefficient of determination (R2), Nash and Sutcliffe efficiency (NSE) and index of agreement (d) were also estimated while analysing the observed water yield and SWAT simulated water yield of Umkhen. Overall, the model was found validated. Analysis of spatial and temporal variation of water yield was performed in the 13 delineated sub watersheds. The variability of input data (soil, land use and weather) has also been found appropriately reflected in model outputs at the outlets of 13 delineated sub-watersheds.

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Worldwide Use of SWAT: 2012 Update

Philip W. Gassman

Abstract

The Soil and Water Assessment Tool (SWAT) has emerged as one of the most widely used watershed- and river basin-scale water quality models in the world. SWAT is being used to address a wide range of water quantity and water quality problems across a tremendous range of watershed scales and environmental conditions. Over 900 peer-reviewed SWAT-related journal articles have now been published and hundreds more continue to be published in conference proceedings and other formats. This 2012 presentation builds on previous papers and presentations, by providing updates regarding model development and application trends for both the standard SWAT code and spin-off models. Updated trends will also be presented for regional use of the model for Africa, Asia, Latin America, North America, and Europe, including large-scale applications that are currently being implemented for several major river basin systems located in these different continents.

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Development of an Intelligent Digital Watershed for Sustainable Agro Economy in the US Midwest

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Abstract

Human activity is intricately linked to the quality and quantity of water resources. Although many studies have examined water-human interaction, the complexity of such coupled systems is not well understood largely because of gaps in our knowledge of water-cycle processes which are heavily influenced by socio-economic drivers. Traditional geographic information management systems lack the ability to support the modeling and analysis of such complex spatial processes. On this context, we propose to develop an Intelligent Digital Watershed (IDW) which fuses emerging concepts of Digital Watershed (DW). Prototype IDW in the form of a cyber-infrastructure based engineered system will facilitate novel insights into human/environment interactions through multi-disciplinary research focused on watershed-related processes at multiple spatio-temporal scales.

In an ongoing effort, the prototype IDW is applied to Clear Creek watershed, an agricultural dominating catchment in Iowa in the US Midwest, to understand water-human processes relevant to management decisions by farmers regarding agro ecosystems. The primary aim of this research is to understand the connections that exist among the agricultural and biofuel economy, land use/land cover change, and water quality. To help explore these connections an agent-based model (ABM) of land use change has been developed that simulates the decisions made by farmers given alternative assumptions about market forces, farmer characteristics, and water quality regulations. The SWAT model was used to simulate the impact of these decisions on the movement of sediment, nitrogen, and phosphorus across the landscape. The paper also describes the cyber infrastructure and workflows developed for connecting the IDW modeling tools and components: ABM, Data-Driven Modeling, and SWAT.

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SWAT Application for Snow Bound Karkheh River Basin of Iran

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Abstract

The main objective of the research is to simulate the snow bound KARKHEH River Basin (KRB) in Iran. The KRB is located in the south west with geographical coordinates between 30° to 35° northern latitude and 46° to 49° eastern longitudes with total area of about 50800 km2. Most of the precipitation (about 65%) falls during the winter months from December to March and almost no precipitation during summer season, i.e., June to September. Hydrological features of the KRB are peculiar and heterogeneous because of its diverse topography and natural settings of geology (karst), climate and ecology. Generally, the basin is characterized by a Mediterranean climate having cool and wet winters and hot and dry summers.

SWAT model has been used for simulation of KRB. The SWAT model has been set up using the data on terrain (90 meter resolution DEM), landuse (90 meter resolution belong ETM+ 2002 image processed), soil type (belong FAO) and local meteorological conditions (belong Iran Meteorological Organization). Two approaches have been used for calibration; i) the manual and ii) the auto-calibration. The One – factor- At – a- Time (OAT) sampling has been used for manual calibration. The Sequential Uncertainty Fitting (SUFI-2) algorithm in the SWAT-CUP program was used for parameter optimization. The evaluation of calibration has been done using Graphically Procedure, Nash–Sutcliffe Efficiency (NSE), Percent Bias (PBIAS), coefficient of determination (R2) and Root Mean Square Error (RMSE).

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Quantification of Urbanization Effect on Water Quality Using SWAT Model in Midwest US

Shashank Singh and Chetan Maringanti

Abstract

Land use change from non-urban to urban land has social and economic benefits but can alter hydrologic processes significantly. Urban land cover provides more impervious surface causing higher hortonian runoff and less infiltration capacity affecting stream and river system. The objective of this study is to assess how increase in urban area (1560 km2) and crop area affect runoff and water quality in Upper White river watershed (7043 km2) in central Indiana, US. Of concern specifically is the potential impact of future developments in the watershed on the increase in stream flow and degradation of water quality. Anticipated increase in imperviousness, on the other hand, is expected to elevate flood risk and the associated environmental damage. The change in land use also has an effect on the hydrologic processes such as soil moisture, surface runoff and evapotranspiration. The study is divided into two components and various estimates were modeled using a distributed watershed level simulation model Soil and Water Assessment Tool (SWAT). Firstly, the impact of land use change (increased imperviousness) on surface runoff in the watershed is analyzed. Secondly, the impact of land use change (increased urban area and crop area) on surface runoff in the watershed is analyzed. The first objective is achieved by changing the curve number (CN) uniformly in the watershed. To accomplish the second objective, land use is reclassified with increase in urban area and crop area by forest land. The result showed a significant change in surface runoff due to change in imperviousness in watershed and also with increase in urban and crop area in watershed.

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Water4Crops: Integrating Treated Wastewater Reuse and Enhanced Water Use Efficiency in Agriculture to Support the Green Economy in EU and India

A. Lo Porto, A. Lopez, A. Pollice

Abstract

This paper aims at introducing the new research project "Water4Crops - Integrating biotreated wastewater reuse and valorization with enhanced water use efficiency (WEF) to support the Green Economy in EU and India". The project addresses the EU call for proposals "FP7 - KBBE.2012.3.5-03: Biotechnological wastewater treatments and reuse in agronomical systems in a joint EU-India cooperation". Two "twin" projects (Water4Crops-EU and Water4Crops-India) were prepared by two distinct consortia and simultaneously submitted for funding to the European Commission and the Department of Biotechnology (DBT) of the Government of India, respectively. The European consortium is made of 22 partner institutions, whereas the Indian one has 14. EU and DBT contributions are about six million Euros for each project, respectively.

This presentation mainly deals with Water4Crops-EU, although most issues and approaches are also shared and adopted by the Indian project.

Water4Crops will last four years (2012-2016) and its main objectives are:

- To develop innovative biotechnological wastewater treatments for improved water use in agriculture.
- To initiate the co-creation of alternative combinations of bio-treatment, recycling of high value elements, and combinations for bio-products leading to a better commercialization of biotechnology and agricultural products in Europe and India as a basis for a "green growth".
- To improve water use efficiency at field level through agronomics, plant breeding and locally adapted new irrigation technologies and accurate crop water requirement measurement techniques.
- To facilitate and enhance the stakeholder participation (technology producers, technology users, retailers, and regulators), activities coordination and exchange of information within the INNOVA co-creation platforms and beyond
- To use the collaborative research with India as means towards food and water security and enabling mutual strive of India and Europe towards a Green Economy.

Technologies developed in India and Europe, both in the field of bio-treatment and increased water use efficiency are basically comparable, but their applications are context-specific and require new adaptations and integration. In order to boost the bio-based economy both in Europe and India Water4Crops will provide a comprehensive set of key technologies (reflecting the highest state of the art in Europe and India) to highlight the differences in processes and applications, and finally to identify the best

possible modifications to achieve a higher and combined use of technological advances from both at both regions. Water4Crops aims not just at a further development of individual technologies, but also at understanding their added value in relatively unexploited fields of application (both in India and Europe).

Therefore, Water4Crops specific objectives are:

- Production of water suitable for irrigation from wastewater (food-processing, domestic or bio-refineries) and return of nutrients as fertilizer to the land.
- Recovery of specific high added value products from wastewater (e.g. polyphenols), anaerobic conversion of wastewater components into organic acids, alcohols coupled with in situ product recovery, production of bio-plastics (Poly hydroxy butyrate) from high carbon wastewater, and energy recovery from the final treatment.
- Development of easy and cheap microbial monitoring methods to control the irrigation water quality in terms of pathogens.
- Optimize domestic wastewater treatment, recycling and discharge via constructed wetlands with control of heavy metal removal, developing new management of constructed wetlands in terms of improved purification capacity and suitable plants selection.
- Development of improved irrigation technologies, systems and strategies, coupling of irrigation systems with soil moisture control and modelling in saline conditions, and provide an accurate estimation of crop water requirements using new technologies for area-based actual evaporation and soil moisture measurements.
- Modelling the impact of using poor quality water on crop and soil quality.
- Improved water use efficiency (WEF) at the field level through genomics and plant breeding.
- Development of a Green Economy by trans-disciplinary co-creation of agri-business opportunities and water bio-treatment and evaluation and optimization of the proposed combinations of water processing from a perspective of supporting the Green Economy.
- Stimulate cross-fertilization and knowledge transfer between the individual work packages and activities in Europe and India.
- Disseminate the newly developed technologies, the new economical concepts and local business demands, and exchange the experience between India and Europe on advancing the Green Economy.

The project is very ambitious and comprehensive, its scope spans from technological issues to the creation of business opportunities for the development of a Green Economy. Strong integration and cooperation among academic and industrial partners with expertise in different fields will ensure the achievement of the proposed objectives. The project will promote relevant advancements in the overall process of knowledge integration among environmental scientists, process engineers, agronomists, biotechnologists and economists in the perspective of improving sustainable resource exploitation.

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Experimental Investigation of Rainfall Runoff Process

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Abstract

For mathematical simulation of rainfall-runoff process, controlled rainfall - runoff experimental runs were conducted on Advanced Hydrologic System to obtain runoff hydrograph data. The experiments were carried out over a non-cohesive sediment layer having sediment particle size of 0.5 mm to 1 mm placed over an impermeable plane surface (smooth metal sheet), with a uniform rectangular cross section of dimension one meter wide and two meter long. The generated experimental data were simulated using a one-dimensional finite difference numerical model of kinematic wave equation for overland flow to investigate the effects of variation of rainfall intensity and surface slope on the overland hydrograph. Experimental data were simulated using developed model in order to study the effect of variation in the slope of the catchment and intensity of rainfall on overland flow roughness. Data was observed for catchment slope between 1 % to 4 % and rainfall intensity between 30 to 90 mm/hr. The comparison of observed and simulated runoff hydrograph reveals that the kinematic wave model simulates the rising, equilibrium discharge and upper part of recession limb of observed hydrograph reasonably well. However, the lower portion of the recession limb of observed hydrograph remained under predicted. The study further reveals that the resistance due to flow decrease linearly with increase in slope for a given rainfall intensity. Also for a given slope of overland flow plane, the resistance to flow decreases with increase in the rainfall intensity. It was observed that for a given rainfall intensity, an increase in the overland plane slope, reduces the time to peak.

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Assessing Climate Change Impacts and Adaptation in Central Vietnam Using SWAT and Community Approach: Case study in Vu Gia Watershed, Quang Nam Province

Nguyen Kim Loi

Abstract

With the changes in climate, biophysical, socio-cultural, economic and technological components, paradigm shift in natural resources management are unavoidably adapt/ modified to harmonize with the global changes and the local communities' needs. This research focused on climatic change risk, vulnerability and adaptation in Dong Giang district in response to climate change impacts as case study. The Soil and Water Assessment Tool (SWAT) model was applied to assess climate, land use change and practice impacts to soil and water resources in Dong Giang district as upstream of Vu Gia watershed, Quang Nam province. This part focuses on the relationship between upstream and downstream in Vu Gia watershed and using sustainable watershed management in response to climate change in Quang Nam province, Vietnam. The research also concerns with changes in ecological and socio-economic conditions driven by climate change and human activities in Dong Giang; and adaptation measures in agricultural production and livelihoods to suit in the new context.

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Rainfall-Runoff Modeling Using Doppler Weather Radar data for Adyar Watershed, India

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Abstract

Precipitation is a significant input for hydrologic models; so, it needs to be quantified precisely. The measurement with rain gages gives the rainfall at a particular location, whereas the radar obtains instantaneous snapshots of electromagnetic backscatter from rain volumes that are then converted to rainfall via algorithms. The primary advantage of Doppler Weather Radar (DWR) observations of rainfall compared to the traditional rain gage measurements is their high spatial and temporal resolution and large areal coverage. It has been proved in many countries that the radar measurement of areal rainfall can outperform rain gage network measurements, especially in remote areas where rain gages are sparse, and remotely sensed satellite rainfall data are too inaccurate.

My research focuses on a technique to improve rainfall runoff modeling based on radar derived rainfall data. A hydrologic model called 'Hydrologic Engineering Center-Hydrologic Modeling System (HEC-HMS)' is used for simulating rainfall-runoff processes, and the gridded precipitation method uses radar rainfall data. HEC and Environmental System Research Institute (ESRI) developed HEC-GEOHMS. It is a set of ARCGIS tools specially designed to process geospatial data and create input files for HEC-HMS. CartoDEM30m is used for watershed delineation using HEC-GEOHMS.

The Adyar Watershed is within 100 km radius from the DWR Station, Chennai, hence it has been chosen as the study area. The JAL Storm event from 6th November 2010 to 8th November 2010 period is selected for the study.

The radar rainfall data is collected from Cyclone Deduction Radar Centre, Chennai. DWR derived products; the Surface Rainfall Intensity (SRI) and Precipitation Accumulation (PAC) are used for the Runoff estimation. The SRI is calculated using the Z-R Relationship (Z=A Rb) where Z is radar reflectivity in mm6 m-3, R is rainfall intensity in mm h-1 and A and b are coefficients. PAC is calculated as a second-level product based on the SRI. There are three non-recording rain gage stations around the study area. The rain gage data is collected from State Ground and Surface Water Resources Data Centre, Tharamani, Chennai.

The development of flood forecasting models and engineering design procedures should be undertaken using radar data because of the benefits of their spatial information content.

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Performance Evaluation and Uncertainty Analysis of SWAT Model for Simulating Hydrological Processes in an Agricultural Watershed in India

Ajai Singh, Mohd. Imtiyaz, R. K. Isaac, D. M. Denis

Abstract

In the present study, Soil and Water Assessment Tool (SWAT), a river basin or watershed scale model was applied to predict the monthly stream flow and sediment yield of Nagwa watershed in Eastern India. The SWAT model was calibrated and validated with the measured stream flow and sediment yield, and quantification of the uncertainty in the SWAT model output was assessed using Sequential Uncertainty Fitting Algorithm (SUFI-2). Weather data, monthly stream flow and sediment yield data from meteorological station near the outlet of the watershed (1991 to 2007) were used for model set up, calibration and validation of the model. ArcGIS 9.3.1 was used to prepare spatial input data such as digital elevation model, land use land cover and soil maps. The coefficient of determination (R2) and Nash-Sutcliffe simulation efficiency (NSE) values were found to be 0.77 and 0.75 during calibration and 0.70 and 0.67 during validation periods for stream flow, respectively. R2 and NSE values of 0.77 and 0.77 for the calibration, and 0.68 and 0.66 for the validation periods, respectively were observed for simulated sediment yield. The values of r-factors were found to be 1.26 and 0.79 for stream flow and sediment yield simulation, respectively, which indicates a wider prediction interval. The values of P-factor show that the percentage of observed stream flow values bracketed by the 95PPU and the SWAT model successfully captured 87% of the measure stream flow data and 82% of the sediment yield data. In other words the SWAT model estimates the stream flow and sediment yield values accurately and with less uncertainty. The SWAT model predictions were quite good keeping in view the approximations and spatial variability involved in simulating the complex hydrological processes.

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Calibration of SWAT Hydrologic Model for the Ilam Dam Watershed in Western Iran

Haji Karimi, Sara Moftian

Abstract

The Soil and Water Assessment Tool (SWAT) model was used to simulate runoff in the Ilam Dam Watershed (477km2) located in the western part of Iran. Model calibration and uncertainty analysis were performed using Sequential Uncertainty Fitting (SUFI_2). Two hydrometric stations namely Golgol and Vizhdarvan in the basin were used for calibration and validation. Four parameters including: P-factor, R-factor, R2 and NS were used for assessing the goodness of calibration and uncertainty analysis. The respective values of above parameters in the Golgol station were: 0.85, 0.86, 0.80 and 0.75 for calibration and 0.76, 0.9, 0.82 and 0.73 for validation respectively. The respective values of the Vizhdarvan station were 0.9, 1.2, 0.80 and 0.75 for calibration and 0.76, 1.5, 0.80 and 0.70 for validation correspondingly. These measures indicate that the model calibration and also the uncertainties related to the predicted runoff in both hydrometric stations were similar to the recorded discharge; i.e., the results were satisfactory.

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Calibration and Validation of a Large Scale Integrated Modeling System: Case of Upper Mississippi and Ohio-Tennessee River Basins in U.S.

Manoj K Jha

Abstract

The Mississippi and Atchafalaya River Basin (MARB) is the largest river basin in the U.S., draining nearly 3 million km2 across 31 states and ultimately discharging into the Gulf of Mexico. An integrated modeling framework using SWAT is being developed with the goal of evaluating possible methods and practices that can potentially ameliorate water quality problems originating in the Upper Mississippi River basin (UMRB) and Ohio-Tennessee River basin (OTB), which are the major MARB agricultural production areas and key MARB nonpoint nutrient pollution source regions. Extensive water quality problems have resulted throughout the UMRB and ORB due to the pervasive nonpoint source pollution problems, and the nutrients exported from the two regions have been implicated as the primary cause of the alarming seasonal hypoxic zone in the northern Gulf of Mexico. The integrated modeling system introduces major refinements for SWAT applications at such large scales in the U.S, with land use, soil, landscapes and management practices defined at the U.S. Geological Survey (USGS) 12-digit watershed scale for subwatershed delineation. This is considerably more detailed than previous SWAT applications for such large systems; e.g., over 5,600 subwatersheds are defined for the UMRB as opposed to previous UMRB SWAT applications that were typically delineated with approximately 131 subwatersheds (based on 8-digit watersheds as classified by the USGS). The success of this modeling application for scenario analyses and evaluation will depend on the accuracy of the calibration achieved. Calibration and validation of SWAT at such a large scale and with such a refined subwatershed and hydrological response unit (HRU) structure, poses major challenges due to increased simulation run-time and increased model parameterization complexity. A systematic approach describing the calibration and validation strategy will be presented including initial results of the overall water balance over various spatial scales including total water yield, evapotranspiration, surface runoff versus baseflow, and other outputs. Manual calibration will be performed during initial stages of calibration, followed by automatic calibration of the entire modeling setup within recommended ranges of model parameters. Hydrologic calibration will be followed by nutrient calibration which will require a different set of parameters and assumptions.

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Evaluating Land USE Land Cover Uncertainty Using Swat 2009_LUC Tool

Dharmendra Saraswat, N. Pai

Abstract

The land-use/land-cover (LULC) map of a watershed is a critical input to the SWAT model. LULC is a categorical geospatial layer that is typically developed based on models that establish relationship between pixel-based spectral reflectance and corresponding ground-truth information. Hence, LULC maps, like other classified remote-sensing data sets, are subject to uncertainty, which is often quantified using confusion matrix. The purpose of this study was to evaluate the effect of LULC uncertainty in SWAT model responses. Multiple realizations of LULC layer were obtained using information present in the confusion matrix while preserving its inter-category class confusions. These alternative LULC realizations were used in concert with the SWAT2009_LUC tool to develop land-use update files and simulate the SWAT model separately for each realization. This approach was tested in a case study under progress for the Illinois River Drainage Area in Arkansas (IRDAA) watershed. The predicted subwatershed responses provided an insight into SWAT model uncertainty that can be associated with LULC changes.

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Adaptation of Multi-Purpose Dam Operation for Two Representativve Dams in South Korea to the Future Climate Change

Jong-Yoon Park

Abstract

South Korea has 15 multi-purpose dams. There are located in upstream areas of the five major rivers (Han, Keum, Nakdong, Yeongsam, and Seomjin Rivers) and the priority for water supply is given to domestic and industrial uses, though the greatest amount of water is still consumed by agricultural purposes. The total reservoir capacity of the developed multi-purpose dams is 11.3 billion m3 this provides an annual water supply of 10,461 m3, flood control of 2.03 billion m3, and 1 million kW of electricity. Operation of multi-purpose dams obviously is sensitive to watershed hydrology depends on climate change. When operation rules are determined based on regional climate condition, we need to evaluate the water supply capacity by hydrologic impact assessment in the future with water demand. The aim of this study is to assess the potential impact of climate change on multi-purpose dam operation for a 6,642 km2 Chungju and 2,703 km2 Soyang dam watersheds on the Han River in South Korea. The climatic data predicted by MIROC3.2 HiRes, ECHAM5-OM and HadCM3 general circulation models (GCMs) data of special report on emission scenarios (SRES) A2, A1B and B1 for two time periods (2020-2059 and 2060-2099) were downscaled using the Long Ashton Research Station – Weather Generator (LARS-WG) stochastic weather generator after bias correction with 30 years (1981-2010) of ground measured data. GCM temperature and precipitation output and historical records are used as input to a hydrologic model to derive dam inflow. If the river is a managed system with reservoirs, a water management or optimization model may be used to model reservoir operating rules. In this study, Soil and Water Assessment Tool (SWAT) was adopted for analysis of hydrologic behavior in two large dam watersheds. Hydrologic Engineering Center – Reservoir System Simulation (HEC-ResSim) was used to simulate water supply by dam operation in the future. The purpose of linking the hydrologic and reservoir operation models was to predict changes in storage and water supply resulting with the future climate change scenarios. The calibrated SWAT and HEC-ResSim models were linked so that output (daily dam inflow) from the SWAT model became input for the HEC-ResSim model. The simulation results of climate change scenarios are expected significant effects on watershed hydrology and multi-purpose dam operation. Especially, changes in dam inflow from the watershed will be affected water use such as water supply, hydropower, irrigation, flood control and mitigation, water quality enhancement into the downstream, and recreation. Therefore, to mitigate negative hydrologic impacts and utilize positive impacts, climate change should be considered in water resource planning for the multi-purpose dam watersheds. To enable adaptation due to climate change as a widely accepted future occurrence, watershed decision makers require quantitative results for the establishment of adaptation strategies. Detailed results and discussions for the adaptation of multi-purpose dam operation to the future climate change will be suggested.

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Assessment of Future Climate Change Impacts on Snowmelt and Its Water Quality for a Mountainous Watershed using SWAT

Kim, Saet Byul

Abstract

This study is to assess the future climate change impact on snowmelt and stream water quality of a 6,642.0 km2 mountainous dam watershed in South Korea using Soil and Water Assessment Tool (SWAT). The model was calibrated and validated for 2000-2010 using daily streamflow data at one location and monthly stream water quality data at two locations. The 6 snowmelt parameters of snowfall temperature, maximum and minimum melt rate, snowmelt temperature, initial snow water content and snow areal depletion curve (SADC) were considered and the multiple sets of Terra MODIS (MODerate resolution Imaging Spectroradiometer) snow cover data were used for SADC parameter of the watershed. For future evaluation, the HadCM3 Special Report on Emissions Scenarios (SRES) A2, A1B, and B1 of the Intergovernmental Panel on Climate Change (IPCC) were adopted. The HadCM3 data were corrected for each bias of weather data and downscaled by LARS-WG (Long Ashton Research Station-Weather Generator) model. The future impact on stream water quality by snowmelt will be discussed for two periods; 2020-2059 (2040s), 2060-2099 (2080s) and compared with baseline period; 1981-2010 (30 years).

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Climate Change Implications on Drought and Flood Situation of the Krishna and Mahanadi River Basins

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Abstract

The present study is an attempt to quantify the impact of the climate change on the water resources of Krishna and Mahanadi river basins. The SWAT semi-distributed hydrological model has been used with regional climate model (PRECIS RCM) outputs as input at daily interval. Initial analysis of outputs under climate change scenarios reveal that the Krishna river basin is likely to be subjected to enhanced droughts whereas the Mahanadi river basin is likely to experience enhanced flooding.

Drought indices are widely used for the assessment of drought severity. The Palmer Drought Severity Index (PDSI) is used for drought analysis. Weekly information required for computation of PDSI has been derived using daily SWAT outputs for subsequent analysis of drought severity. Variability in moisture condition is expected to increase for MC (Mid-century) and stabilize in EC (End-century) scenario for the Krishna river basin. An annual increase of about 2 to 3 weeks under drought is expected in MC.

Flood analysis has been carried out using the daily outflow discharge taken for each sub-basin from the SWAT output. These discharges have been analysed with respect to the maximum annual and daily peaks. Two kinds of analysis have been performed, (i) change in the magnitude of flood peaks above 99th percentile, 95th and 90th percentile flow has been evaluated and (ii) flow duration curves have been plotted for the Mahanadi river basin. The increase in peak discharge of 40% and 50% has been predicted respectively from baseline to MC and EC scenarios.

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Assessing Water Discharge in Be River Basin, Vietnam Using SWAT Model

Nguyen Kim Loi

Abstract

This study applied SWAT (Soil and Water Assessment Tool) Model to assess water discharge in Be river basin, Vietnam. The water discharge is an important hydrological parameters which de?nes the shape, size and course of the stream. The results of monitoring flow discharge can be useful information for flood forecasting, predicting sediment loads and assessing the impact of climate change to water resource. The study focused to quantify the impact of topographic, land use, soil and climatic condition on water discharge in Be river basin, Vietnam using SWAT model. In this integration, GIS supplies SWAT input data included elevation, soil properties, land use and weather data and creates graphical user interface for SWAT, while SWAT operates input data, delineates watershed, simulates different physical processes, displays output data as discharge. The simulation results in the period 1979 to 2007 represented fluctuation of discharge relatively well with both R2 and NSI values were above 0.7 in the period 1979 to 1994. This result can be used for predicting the effect of changing land use and conservation pratices on water discharge within the basin, helping to water quantity and quality assessment.

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Critical Review of Hydrological Models for Climate Change Impact Assessment

Dr. Raj Kachroo

Abstract

Weaknesses of Semi Distributed Conceptual Models for use in impact assessment of changes in climate or catchment characteristics or for use as a core of an Integrated Decision Support system are discussed in this paper. SWAT model is chosen as an example because it is a popularly used Semi Distributed Conceptual Model for such impact assessment. This paper presents a discussion on the suitability of Nash Sutcliffe Criteria, commonly used as an evaluation criteria for applications for Climate Change impact applications and concludes that this criteria may not be suitable for such applications. The paper suggests a suitable methodology of Modeling for climate change impact.

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Integrated Hydrologic Modeling Framework: Eb_Et-Swat-Modflow

Jorge A Guzman

Abstract

The Soil and Water Assessment Tool (SWAT), MODFLOW, and Energy Balance based Evapotranspiration (EB_ET) models are extensively used to estimate different components of the hydrological cycle. Surface and subsurface hydrological processes are modeled in SWAT but limited to the extent of shallow aquifers while MODFLOW concentrate on groundwater movement. Therefore, neither SWAT nor MODFLOW can independently simulate the full extent of the hydrological cycle at the watershed scale. Further, spatially variable recharge inputs to MODFLOW are normally assumed constant and estimated as a percentage of rainfall, which is does not realistically represent this spatial and temporally variable and management responsive process. In this study, a framework coupling SWAT (v. 477) and Newton Formulation for MODFLOW-2005 (MODFLOW-NWT) was developed to allow interaction of fluxes between SWAT hydrological units (HRUs) and MODFLOW-NWT grids at user defined time steps. Also, new tools were developed using DELPHI programming language in Windows environment to assist users to develop and setup the coupled models. The integrated SWAT-MODFLOW-NWT model system was evaluated using the Fort Cobb experimental watershed datasets for the period 2005-2010. Measured groundwater levels from the underlying Rush Spring aquifer and flow data at daily time-step from four USGS gauges located within the watershed were used for this purpose. Calibration and validation results from this study will be presented and discussed. The next phase will involve incorporating an EB_ET model that can provide improved evapotranspiration (ET) estimates to calibrate or substitute for ET in SWAT model.

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A Comparison of Stream Flow Prediction Using Station and Gridded Meteorological Datasets in IRAN

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Abstract

Accuracy and precision of hydrological simulations depend on the quality and quantity of the input requirements, mainly climatic data. This paper focuses on comparing the effect of two different climate datasets on the prediction of river discharges across Iran. Soil and Water Assessment Tool (SWAT) in combination with SUFI-2 program was used for simulation of the eight main hydrologic regions (HR) in Iran. The two climate datasets were: i) the observed data of 150 synoptic stations obtained from the public Weather Service of the Iranian Meteorological Organization (WSIMO), and ii) the gridded climate data of Climatic Research Unit, University of East Anglia (CRU TS3.0 global), with 0.5 degree resolution (about 1200 grid points covering entire country). The study period was 1987-2002 considering 3 years of warm-up period. Four SWAT projects were created to address the effect of two climate datasets and two different discretizations delineating 506 and 1269 subbasins. The results showed that compare to the local observational datasets (150 stations) the CRU gridded dataset (1200 stations) performed well when simulating river discharge in most of the HRs in Iran. The improvement was significant when more subbasins were delineated using SWAT model. We concluded that the CRU high resolution grid dataset is useful for the hydrological simulation in Iran, but a balance must be reached between the number of stations and the resolution of the subbasins delineation. This study conveys the important message that the global CRU climate data can be used in regions of climate data scarcity with high confidence.

Comparison of Grid-based and SWAT HRU Modeling Approaches for Evaluating the Climate Change Impact on Watershed Hydrology

Hyuk Jung

Abstract

The aim of this study is to compare the results of grid-based and Soil and Water Assessment Tool (SWAT) HRU (hydrologic response unit)-based modeling for evaluating the climate change impact on watershed hydrology. The grid-based model is a typical distributed hydrological model which divides the watershed as a cell base and calculates the water balance of each cell by constructing 3 vertical layers of surface, subsurface and groundwater flow. SWAT is a well-known hydrologic response units (HRUs)-based model, which are portions of a subbasin that possess unique land use, management, and soil attributes. For a 930.4 km2 Yongdam Dam watershed located in the middle of South Korea, the 2 models will be calibrated and validated using 10 years (2001-2010) daily streamflow data at multiple locations including couple of year soil moisture and evapotranspiration data, and the Nash-Sutcliffe model efficiency will be suggested. For the future climate change scenario, the MIROC3.2 hires A1B and B1 scenarios were prepared for 2040s (2020-2059) and 2080s (2060-2099) using the Long Ashton Research Station - Weather Generator (LARS-WG) model. The future hydrologic components will be compared as both integrated results and spatially distributed results.

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Hydrological Modeling Using SWAT Model to Identify Critical Erosion Prone Areas in Barakar Basin

N. S. Raghuwanshi, Amit Kumar Singh, Bidhan Sardar, Chandranath Chatterjee

Abstract

Extensive soil erosion and its attendant ills have already contributed very significantly to the impoverishment of the land and people of India. It is estimated that one third of the arable land is likely to be lost within the next 20 years if the present trend is allowed to continue. Effective control of soil and nutrient losses requires identification and management of critical erosion prone area through implementation of the best management practices. The use of physically based distributed models, remote sensing technique and geographical information system can assist management agencies in both identifying most vulnerable erosion prone areas and selecting appropriate management scenarios. In the present investigation, an effort was made to identify the critical erosion prone areas of the Barakar basin (6293 km2) in Jharkhand state, India with the help of spatially distributed hydrological model, namely Soil and Water Assessment Tool (SWAT). This effort is extremely necessary before adopting any suitable soil conservation measures to reduce soil erosion. Daily rainfall and air temperature, and monthly runoff, sediment yield and reservoir inflow data of 5 years (1997-2001) were used in this study. Besides these data, the topographical map, soil map, land resource data and satellite imageries of the area were used in this study. The model was calibrated and validated for the peiod of 1997-99 and 2000-01, respectively, for monthly inflow to two reservoirs (Maithon and Tilaiya). In addition, it was also calibrated and validated for the monsoon months of the same period for monthly runoff and sediment yield from four sub-watersheds (Banha, Karso, Santrabad and Rajdhanwar), located within Barakar basin. The calibration and validation results established good agreement between observed and model predicted values in all cases. The identified critical areas through model predicted sediment yield were verified with results of report of Soil Conservation Department of Damodar Valley Corporation (DVC), Hazaribagh. It was found that erosion class map developed using simulation results matched spatially well with the DVC prepared map. These results suggest that SWAT can be used to identify critical sub-watersheds to control erosion.

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Using ArcSWAT for Evaluation of Water Productivity and Economics of Crops in Canal Irrigation Command

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Abstract

Crop water use efficiency (WUE, yield per unit of water use) is the key for agricultural production with limited resources. Policymakers and water resource managers working at all scales need to address the multitudinous scenarios in which cropping systems and amounts, timing and methods of irrigation may be changed to improve WUE while meeting yield and harvest quality goals. Experimentation cannot address all scenarios, but accurate simulation models may fill in the gaps. Implementing real water saving measures in irrigated agriculture is only possible if all the components of the current water balance are clearly understood. However, measurement of all the terms in the water balance is infeasible on a spatial and temporal scale, but hydrological simulation models can fill the gap between measured and required data. To obtain all the terms of the water balance for Sina irrigation command in Maharashtra state, India, GIS based SWAT model was used to evaluate crop response to different irrigation depths, estimate the crop yield and water productivity. The water productivity was calculated and net crop returns of different crops grown in different soils of irrigation command were critically analyzed for limited water application.

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Towards Evaluation and Prediction of Soil Erosion for Entire Region of North Vietnam Using SWAT Model

Nguyen Duy Binh

Abstract

The growing population and the increasing food demand in Vietnam lead to intensification of land use for agricultural activities. Soil degradation in sloping lands such as erosion by water is one of consequences that necessitate enhanced land use planning and management at regional and national levels. The present study is an attempt to analyses of soil erosion status in North of Vietnam using the well-known SWAT (Soil and Water Assessment Tool) model. With the purpose of improving validation of the SWAT for North Vietnam, in addition to data of topography, climate, hydrology, soil, land use, and agricultural practice, this study tried to use data from soil erosion experiments that have been conducted in the past. Modeling results from SWAT were also compared with those from process-based WEPP (Water Erosion Prediction Project) model in selected watersheds where measured data of soil loss is available. The study results shows that SWAT set-ups was acceptable in simulation of water flow in many watersheds but has mixed validation results when comparing with soil loss measurement data and with WEPP model output. Results of the study will be used for further evaluation and prediction of soil erosion for the whole Vietnam territory.

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Application of a Basin Scale Hydrological Model for Characterizing Flow and Drought Trend

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Abstract

Drought analysis is an essential issue for water resources planning and management to reduce the severity of drought damage, especially, it has been an argument that climate change will extremely affect to water scarcity in the future. The objective of this study is to investigate impacts of climate change on streamflow drought characteristics in the Chi river basin, Thailand. For drought analysis, we used 0.25 degree grids of the observed precipitation data for 30 years (1975-2004) for the present period and the downscaled MIROC GCM precipitation data under A1B

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Hydrological Modelling of Son and Ton River Basin Using SWAT

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Abstract

River Ganga which is recently declared as the national river of India is one of the heavily polluted rivers in India. The government of India has formed the NGRBA to regulate the river basin activities in Ganga. One of the major goals of NGRBA is to prepare and implement a management plan, for which a mammoth hydrologic modeling exercise is underway. The current study describes about the Hydrological modelling of Son and Ton river basins, two of the major non Himalayan rivers of river Ganga, using SWAT. Son is one of the larger basin within the Ganga system with an area of 1,71,884 square kilometres, Son basin falls in the state of Uttar Pradesh, Madhya Pradesh, Jarkhand, Chattisgarh and Bihar . The Ton basin falls in the states of Uttar Pradesh and Madhya Pradesh. The major crops grown in both these basins are Paddy, Wheat, Maize, Jowar, Barley, Bajra, Urad, Moong and Sugarcane. Son basin has 20 bigger water bodies out of which there are 12 are man made reservoirs and the remaining eight of them are lakes. Ton basin comprises an area of 48,180 square kilometers and it has 8 reservoirs in it. Irrigated agriculture account for about 42% and 22% respectively of the total basin area of Ton and Son river basins. Detailed crop and irrigation management practices that reflect the ground conditions are simulated with the SWAT model. The generated flow will be verified with available discharge data from the gauging stations in these basins at Sathna and Kuldha Bridge. The results from this study will indicate the spatial and temporal availability of water in surface and subsurface in the basin. This information is critical for the development of an effective river basin management plan.

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Localised Variations in Water Scarcity: A Hydrologic Assessment Using SWAT and Spatial Techniques

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Abstract

Water scarcities of different orders are experienced all over the world. Water availability is not assured even in places with ample receipt of annual rainfall due to the steady decline of natural water conservation as an after effect of unscrupulous changes in land uses and unscientific human interventions under the guise of development. Further, water availability shows high variations between localities with very little geographical separation and almost similar climatic conditions. Major parts of the state of Kerala can be cited as typical examples for the said water paradox.

Hence, a study has been conducted for the Kunthipuzha tributary of Bharathapuzha river basin, one of the major rivers of Kerala, having a catchment area of 822 km2 to throw scientific insight to the issue of variations in water availability between localities of close geographical proximity. SWAT has been used to delineate the micro-watersheds and to quantify various hydrologic processes on a smaller spatial and temporal scale. GIS has been used to consolidate the water availability in administrative divisions of local self governments (Grama Panchayaths and Block Panchayaths).

The study shows that there is very high variations (more than 70% of the mean value) in different hydrologic processes such as surface runoff, lateral flow and base flow between the micro-watersheds. It is reflected in the water availability within the administrative divisions of local self governments. It is hoped that the study can go a long way to help in giving a scientific framework for water management activities of these institutions.

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Simulation of Sub-Daily Runoff for an Indian Watershed Using SWAT Model

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Abstract

In India, integrated watershed management has been adopted as a part of the National Water Policy for planning, development and management of water resources. Simulation of sub-daily runoff at watershed level is important to understand the prevailed hydrologic regime of the watershed. This will help in the effective planning and management of water resources at watershed scale. A robust and generic watershed model is required for simulation of runoff at sub-daily time steps by considering the important hydrological processes of the watershed. Soil and Water Assessment Tool (SWAT) model developed by the United States Department of Agriculture is one such widely used model in simulation of hydrologic and water quality parameters. SWAT model is a hydro-dynamic and physically-based hydrologic model. Geographic Information System (GIS) provides the framework within which spatially-distributed data are collected and used to prepare model input files and to evaluate model results. SWAT model with GIS tools, can be used to illustrate the effects of land use practices on runoff, and to support the spatial analysis of hydrologic parameters of the watershed. Arc SWAT model is the modified version of SWAT model with can work in the Arc GIS environment. This paper presents the application of Arc SWAT model in simulation of sub-daily runoff in Indian watershed. Harsul watershed located in Nashik district, Maharashtra, India has been selected to test the application of Arc SWAT model under Indian conditions. The watershed is relatively small with sufficient data on soils, land use, climate, and water flow. The watershed has an area of 10.929 sq.km. Hourly rainfall data, Land Use (LU)/ Land Cover (LC), Soil data and Digital Elevation Model (DEM) data of the watershed has been used to simulate the runoff of the watershed. Calibration and validation of the model has been performed by using the observed runoff data. The simulated flow data has been compared with observed data and found to be satisfactory. The methodology presented in this paper will be useful for simulation sub-daily runoff in Indian watersheds using Arc SWAT model.

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A Simplified Channel Routing Scheme Suitable for Adoption in SWAT Model

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Abstract

A suggestion for replacing the existing channel routing schemes, based on the variable storage routing method and the Muskingum method, adopted in the SWAT model by a Variable Parameter McCarthy-Muskingum method recently proposed by Perumal and Price (2012) is presented in this study. This fully mass conservative routing method is derived from the Saint-Venant equations and is suitable for routing floods in natural river reach when there are only surveyed channel cross-sections at a few gauging stations along the reach with rating curves available only at the two-end sections. It is assumed that the natural river reach can be approximated to that of a prismatic channel reach, including floodplains. The non-linearity of the routing process is taken care off by varying the parameters of the Muskingum method, which are linked to channel and flow characteristics, at every computation level. The paper also demonstrates using field data that the performance of the method is far better than the currently available variable parameter Musingum-Cunge method and the variable parameter Muskingum-Cunge-Todini method in reproducing the observed hydrographs. A routing procedure using this method is presented herein developed based on the reach-averaged rating curve and cross-section data. The methodology is demonstrated using field data of natural rivers.

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Impact of Agricultural Intensification on the Water Resources in a Semi-Arid Catchment in India

T.V. Reshmidevi, D. Nagesh Kumar

Abstract

Agricultural growth and water resources sustainability are the two critical conflicting issues, particularly in the semi-arid and arid regions in India. In the present study, ArcSWAT(v.2009) has been used to analyse the impact of agricultural intensification on the surface and sub-surface water resources in the Malaprabha catchment in India. The unsustainable cropping pattern of the area, incompatible with the climatology, has given rise to excessive irrigation demand, which is met largely by tapping the aquifer, resulting in a drastic depletion of the groundwater table. The deep aquifer component in SWAT was found to be insufficient to represent this excessive groundwater depletion scenario of the area. Hence, a separate water balance model was developed for the deep aquifer, taking the deep aquifer recharge and irrigation extraction from the SWAT simulation. In order to have a better representation of the catchment climatology multi-site rainfall data was used as an input to the model. Using the present land use/ land cover map, the model was calibrated for the observed monthly stream flow. The calibrated model was further applied for the historic time period, and was found to be equally good for the stream flow simulation, indicating a less influence of the land cover change on the stream flow. On the other hand, the deep aquifer simulation shows more than 100m depletion in most of the areas in the catchment. This excessive groundwater withdrawal would result in the considerable depletion of the ground water resources. In the context of climate change, where an increase in the temperature and a change in the rainfall pattern is expected, the model can be used to estimate the groundwater recharge and the irrigation demand, so as to develop sustainable agricultural plans for the area.

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Sensitivity Analysis of Major Parameters in a Tropical Climate Case Study: Tabma Subbasin, Thailand

Orachorn Kamnoet, Chaiyuth Chinnarasri

Abstract

Sensitivity analysis is the process of determining the rate of change in model output with respect to changes in model input parameters. The parameter sensitivity analysis is important and is a difficult process in the application of the distributed hydrological model. This paper discusses the sensitivity analysis method in SWAT model to a tropical climate, Tabma subbasin in Rayong province, Thailand.

Thematic maps for the model are digital elevation model (DEM) in 2000, soil series map in 2000, land use map in 2001, and drainage network. DEM is prepared from the topographic map in scale 1:50,000. Other data used in this study are drainage areas, stream, irrigation area, and historical hydrological which was assessed by using rainfall trend analysis. The period data for calibration and verification processes are between 2001-2002 and 2003-2005, respectively. Good agreement between observed and simulated discharge, which was expressed by coefficient of determination (R2) and Nash Sutcliffe efficiency (NSE), were found.

The most sensitive parameters were: soil evaporation compensation factor (ESCO), initial SCS Curve Number II value (CN2), base flow alpha factor (Alpha BF), saturated hydraulic conductivity in main Alluvium (Sol K) and available water capacity (Sol AWC) while the most sensitive sediment parameters are channel cover factor, USLE equation support practice factor, exponent parameter for calculating sediment in channel sediment routing and minimum value of USLEC factor for land cover/plant.

Alpha_BF or the base flow recession coefficient is a direct index of ground water flow response to changes in recharge. The soil evaporation compensation factor or ESCO controls the soil evaporative demand that is to be met from different depths of the soil. CN (curve number), contribute directly to surface runoff generation. Soil moisture characteristics, Sol_AWC or plant available water, is estimated as the difference between the field capacity and the wilting point. Sol_K or saturated hydraulic conductivity relates soil water flow rate to the hydraulic conductivity.

The results from this study indicated that the identification of certain SWAT parameters could be limited and lead to finality problems in calibration. The sensitivity of model parameters was closely connected to the climatic and hydrologic characteristics of the watershed. The sensitivity index of ESCO was greater for the Illinois watershed as the evapotranspiration process was a dominant control of the soil moisture in this basin.

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Parallelizing SWAT Calibration in Windows using SUFI2 Program

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Abstract

To conduct a large scale hydrological model at high special and temporal resolution, a calibration algorithm was revised utilizing cluster parallel computing. In large-scale hydrologic models time is often a major impediment in the calibration and application of the hydrological models. To overcome this, most projects are run with fewer simulations, resulting in less-than-optimum solutions. In this paper we explain a methodology where a parallel processing scheme is constructed to work in the Windows platform. We have parallelized the calibration of the SWAT (Soil and Water Assessment Tool) hydrological model, where one could submit many simultaneous jobs taking advantage of the capabilities of modern PC and laptops. This offers a powerful alternative to the use of grid or cloud computing. Parallel processing is implemented in SWAT-CUP (SWAT Calibration and Uncertainty Procedures) using the optimization program SUFI2 (Sequential Uncertainty FItting ver. 2). We tested the program with large, medium, and small-size hydrologic models on several computer systems, including PCs, laptops, and servers with up to 24 CPUs. The performance was judged by calculating speedup, efficiency, and CPU usage. In each case, the parallelized version performed much faster than the non-parallelized version, resulting in substantial time saving in model calibration. The results of this study also show that it is feasible to calibrate a large scale hydrological model at high resolution within a reasonable time without demanding significant computing resources.

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Tropical Land Use Scenario Analysis Using SWAT

Hadi Memarian

Abstract

In recent decades, Hulu Langat Basin as a strategic water catchment in Malaysia has been exposed to extensive changes in land use pattern and consequently hydrological condition. In this work, the impacts of land use/cover change on the basin hydrological condition (water discharge and sediment load) was investigated using the Soil and Water Assessment Tool (SWAT). Model calibration and uncertainty analysis were performed using the Sequential Uncertainty Fitting (SUFI-2) algorithm. Four land use scenarios were defined for land use change impact analysis, i.e. past, present (baseline), future, and water conservation plan. The optimized model was run using different land use maps over the periods 1997-2008 and 2002-2004 for water discharge and sediment load estimation, respectively. The model robustness for water discharge simulation during the period 1997-2008 was good. However, due to uncertainties in the conceptual model, its robustness for sediment load simulation was only acceptable for the validation period of 2002-2004. SWAT simulation using past scenarios resulted in 1.03-6.38% and 12.98-51.69% reduction in monthly direct runoff and monthly sediment load, respectively, as compared to the baseline scenario. SWAT simulation based on the future scenario caused 2.37% and25.59% increase in monthly direct runoff and monthly sediment load, respectively, as compared to the baseline scenario. Hydrological simulation based on the water conservation scenario resulted in 2.76% and 27.48% relative decrease in monthly direct runoff and monthly sediment load, respectively, as compared to the baseline scenario.

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Re-dimensioned CFS Re-analysis Data for Easy SWAT Initialization

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Abstract

Many water resource, hydrological, and climate modelling applications require long and reliable time sets of meteorological data, but in many regions this is often lacking. Gridded reanalysis meteorological data sets from many organizations offer one solution to fill this gap. A number of studies have been published demonstrating the potential of meteorological reanalysis data to drive watershed models, particularly in 'ungauged basins'. While publicly available, these data sets are extremely large, dimensioned for optimal use spatially, often with worldwide coverage and individual time steps. Where data are only required for individual watersheds it is currently necessary to download and process an entire data set of several Terabytes in size in order to obtain a single point through time. If the data sets are re-dimensioned and made available as a temporal series of grid points rather than the current format, a single small basin (<1400km2) would require 3Mbytes, or only about 1/165000 of the dataset in the case of the Climate Forecast System Reanalysis (CFSR) using a degree (~38 km global average) resolution.

We present the following, the potential increased performance of data access for watersheds in different regions of the world, using the re-dimensioned CFS Reanalysis dataset;and an example interface that can be integrated into the current SWAT initialization systems (ArcSWAT and MWSWAT).

We believe that any person with the ability to perform a SWAT initialization using these interfaces, and with internet connectivity, will easily obtain a 30 year history of forcing data, as required by SWAT. We will make available a short informal course covering the current methods to utilize the data in standard ArcSWAT based projects.

Applying Climate Reanalysis Data (CFSR) to Force Watershed Models in the Ethiopian Highlands

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Abstract

Hydrological, watershed, or crop models require a time series of climate data to drive algorithms, but in many areas of the world historical and real-time meteorological gauge data can be sparse or non-existent. Throughout the developing world if gauge data exist the records are often incomplete or unreliable, may come from stations far from the area of interest, and acquiring the data can be a long and expensive process. This is not to mention that the nearest weather station is often too distant to adequately represent local conditions and specific events or storms. In practice, watershed modelers routinely utilize data from the closest recording weather station and then calibrate the model to optimize agreement between observed and simulated stream discharge, reserving a subset of the data for corroboration/ validation. This poses a number of issues (e.g, unintended bias, unrealistic parameter values) that warrant the investigation of new approaches. The density of real-time reporting weather stations can vary from ~60 km between stations in the US to 600 km between stations in parts of Africa, and previous research has demonstrated that stations as close as 30 km apart often show almost no correlation in daily precipitation.

This study presents an alternative methodology for obtaining climatic forcing data by utilizing the National Centers for Environmental Prediction (NCEP) Climate Forecast System Reanalysis (CFSR). The CFSR data are available globally at a 38 km spatial and hourly temporal resolutions. We use a subset of the 30-year temperature and precipitation rate global coverage to force the Soil and Water Assessment Tool (SWAT), initialized for three catchments in the Ethiopian Highlands having varying degrees of weather station data availability. We optimize the SWAT2009 parameters using each set of forcing data to maximize the Nash-Sutcliffe Efficiency between modeled and measured stream discharge at the watershed outlets, and we assume the dataset that produces the best agreement between measured and modeled results, is most representative of the local conditions. Results show that utilizing the CFSR precipitation and temperature data can provide as good or better predictions of watershed discharge than the nearest land based stations. The CFSR method shows promise, particularly for use in data scarce regions.

Assessment of Climate Change Impact on Surface Water Availability in Koshi River Basin

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Abstract

Koshi is a largest river in Nepal and it is one of the tributary of Ganges. Taking Chatara as the basin outlet, the Koshi basin has total catchment area of 57,760 km2. Assessment of surface water availability is a great challenge in Nepal mainly due to data limitations. In this study, the Soil Water Assessment Tool (SWAT) was used to simulate the water availability in the study basin. The impacts of CC projections from average downscaled values from 4 GCM (CNRM-CM3,CSIRO-Mk3.0,ECHam5 and MIROC 3.2) outputs on the hydrology of the basin were also calculated. Mean annual precipitation in the basin is 1230 mm under current climate scenario, whereas 781 mm from 2030s and 818 mm from 2050s climate projection scenarios. Furthermore, annual maximum and minimum temperature is projected to increase by 0.26 C and 0.24 C respectively in every ten years within the Koshi basin.

Result from model simulation shows that annual flow volume is about 52,731 MCM in the Koshi basin under current climate scenario. Annual flow volume will reduce by 1% from 2030s and increase by 3% from 2050s climate change projection scenarios. A seasonal simulation result shows that the highest flow reduction will occur in spring (nearly 14%) whereas highest flow increase will occur in autumn (nearly 22%) in 2050s climate projection scenario.

Implementation of the SWAT Modeling in Two Andean Watersheds as a Tool to Determinate the Hydrological Ecosystem Services and Identify Service Providing Units

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Abstract

Hydrological models are being developed in order to predict the impacts of agricultural activity and land-use transformation on the quantity and quality of surface and sub-surface water. In this regard, their results are useful for defining providing units of water-related ecosystem services in watersheds, an important aspect to consider for the design of schemes rewarding ecosystem stewards. In this sense, The SWAT model constitute a valuable tool to quantify and to define the hydrological environmental services in watersheds. However, in order to obtain accurate results from the application of these models in the Andean watersheds it is necessary to first carry out research into the particular characteristics of the Andean hydrologic cycle. The Andean series of basins are characterized by significant landscape diversity, resulting from a wide variety of soil types, land uses and angles of slopes which, in turn, combined with changes in climate along the altitudinal gradient, create different hydrological responses within the same basin. This diversity poses difficulties for the hydrological models used to simulate the behavior of stream-flow. Despite these challenges, new process and research input have, in combination, improved the performance of these models for simulating the Andean context.

This presentation shows the results from basin modeling in the Andean basins of Rio Cañete (Peru) and Riogrande (Colombia) where the SWAT modeling tool was employed. In both basins there is interest in designing a payment for environmental services scheme and to this end the SWAT model has been used to provide input about the areas of greatest hydrological importance for the watersheds. The application of this model in two different Andean region basins has permitted analysis and assessment of the model's efficiency to be undertaken in situations of contrasting environmental conditions, and with differing levels of information. The Cañete River Basin (5794 km2) is characterized by: dry climatic conditions; evident impacts of glacial melting; comprising a wide variety of altitudes; steep slopes; exposed soils in the drier and steeper areas; and the presence of crops in flat irrigated areas. In contrast the Riogrande basin (1038 km2) features: extensive and intensive farming; moderate to steep slopes; high levels of rainfall throughout the year; little variation in altitudes; and the absence of irrigation systems (rainfall being the main water source).

There is comparatively less information about Cañete (given the fewer stations per km2) than for Riogrande, for

which information (on soils and land use) was of better resolution and with greater number of stations per km2. The SWAT models generated in the two cases high levels of correlation between measured and simulated flows; however, model efficiencies differed according to the Nash-Sutcliffe Index. According to this, daily simulation in Cañete was found to have an index of 0.3, while in Rio Grande this was recorded as 0.42 and monthly simulation was 0.60 and 0.73 respectively. Although in both cases the value was above 0, the Riogrande basin results clearly indicated the model's better performance.

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This presentation discusses the main factors underpinning efficient SWAT simulations in Andean watersheds; it further considers the model's potential to support design of payment for environmental services schemes including its ability to simulate of the effects of changing the land use, management practices, and climate, etc; on the quantity and quality of surface and sub-surface water.

Simple Toolbox for Worldwide Topography Based Soils Reclassification for Initialization of SWAT

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Abstract

Topography is a critical control for multiple watershed processes, including hydrology, surface energy budgets, and soil genesis. Recognizing this we propose integrating topography explicitly into the SWAT model initialization procedure. To do this we have developed an ArcTools extension that interfaces directly with Arc SWAT, and processes the requisite data layers, updates the SWAT databases, and creates the SWAT look up tables We introduce a simple to use, single step toolbox that adds the topographic information, Aspect, Elevation, and Topographic Index (TI) to the vector FAO Global Soils dataset; builds a soil raster layer at the resolution of the project's base Digital Elevation Model; and creates the ArcSWAT and MWSWAT required 'usersoil' database table along with the corresponding soil lookup database table required to map the specific raster soil values to the soil parameters in the 'usersoil' table. This toolbox effectively creates a new soil dataset with topographic features, represented at the resolution of the base DEM, which can be used to better represent the governing energy budget and hydrologic features of the soils, as well as will allow potential redistribution of local soil characteristics such as soil organic matter and soil horizon depths, shown to be heavily correlated to the local topography.

Unfortunately, the STATSGO soil dataset is limited to the United States (US), and does not represent topographical features within smaller catchments. MWSWAT (Map Window SWAT) has included soils parameterization of the raster version of the FAO Digital Soil Map of the World (DSMW), though it is not currently included in the more popular ArcSWAT interface, and is of extremely low resolution for defining any topographical soil characterizations. An updated version of Harmonized World Soils Database (HWSD) to be incorporated within the ArcSWAT interface is currently under development, but while the HWSD will allow simpler initialization for worldwide projects, it too is of too coarse a resolution to represent finer topographical features. This is unfortunate since there has been much research performed to integrate processes that require soil and topographic characteristics that are finer in detail than what default SWAT initialization systems currently include or will include in the near future such as process based snowmelt. This is especially for SWAT modeling projects outside the United States.

High Resolution Integrated Weather-Flood Modeling Framework

Rashmi Mittal, Thomas George, Vaibhav Saxena, Lucas Villa Real, Merlin Davis, Yogish Sabharwal, Ulisses Thibes Mello

Abstract

Recent years have witnessed a huge spike in the incidence of severe storms in several large cities in the world. These storms often lead to floods, which in the absence of early warning systems not only threaten public safety, but also take an enormous toll on the economy due to the impact on transportation, water and energy systems. Accurate coupled weather-flood forecasts with sufficient lead time, are, therefore, extremely critical for planning operations in various socio-economic sectors.

In this work, we present an integrated weather and flood modeling framework that uses WRF-ARW for high resolution weather forecasts and a custom numerical kernel for solving the diffusive wave equations representing the overland fluid flows. The flood model is based on a finite volume method and uses 3rd order Runge-Kutta time integration scheme. The primary goal of this work is to make high resolution simulations (order of few meters) for flood flows covering large spatial domains. The model employs 2D structured high resolution cartesian mesh for capturing local terrain effects. To run such compute intensive models, we have written a parallel code to run on multi-core architectures. Precipitation from the weather model has been provided as input to the flood forecasting model for performing one way coupling. We considered two flood-prone large tropical regions, City of Rio de Janeiro and Brunei, as case studies for our work. The model results were validated with the available observations and look encouraging.

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Hydrological Evaluation with SWAT Model and Numerical Weather Prediction for Flash Flood Forecast System: A Case Study for Upper Nan Basin in Thailand

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Abstract

Flash flood is natural disaster that occurs annually, especially in mountainous terrain with steep slope in the northern Thailand. The current flood forecasting systems and tools are available but low accuracy and efficiency. The numbers of rainfall and runoff stations are less because the access to the station area is difficult, also the operation and maintenance costs are high. Hydrological modeling of a Soil and Water Assessment Tool (SWAT) was used in this study with the application of 3-day weather forecast from the numerical weather prediction model (Numerical Weather Prediction, NWP), which provided temperature, relative humidity, rainfall, sunshine, and wind speed. The data from NWP and SWAT were used to simulate runoff for Nan River in the last 10 years (2000-2010). It was found that the simulated flow rate for the main streams using data from NWP were higher than the observations. At the N64 and N1 stations, the ratios of the maximum simulated flow rate to the observations were equal to 108% and 118%, respectively. However, for the tributaries, it was found that the simulated flow rate using NWP data was lower than the observations, but it was still in acceptable range of not greater than 20%. At N65, d090201, and d090203 stations, the ratio of the maximum simulated flow rate were 90.0%, 83.0% and 86.0 %, respectively. This was because the rainfall from the NWP model was greater than the measured rainfall since the NWP rainfall was distributed all over the area while the rainfall data from the measurements were obtained from specific points. Therefore, the rain from the NWP model is very useful especially for the watershed area without rain gauge stations. In summary, the data from the NWP can be used with the SWAT model and provides good result even though the value for the main river is slightly higher than the observed data. The output can then be used to create a flood map for flash flood warning in the area.

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Real Time Flood Forecasting of Bagmati River Basin India (Bihar) Using SWAT model

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Abstract

Developments in computer technology have revolutionized the methodology of real-time flood forecasting. Several computer-based models have been developed for real-time flood forecast applications. In present scenario real-time flood forecasting 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. This paper describes some modifications made in the SWAT model for its use as real-time flood forecasting model. Integration of the SWAT model output with HEC-RAS model has been done for real-time flood forecasting and inundation mapping of Bagmati river basin of Bihar. Two subroutines have been developed and integrated into SWAT model for enabling it for hourly simulation and forecasting flows at outlet points of different sub-basins. Subroutines have been modified to capture the final conditions of the catchment at any desired instant. This study demonstrates the potential of SWAT for application in real-time ood forecasting and forecasted inundation mapping.

A real-time flood forecast application study of the Bagmati river basin in Bihar, India, using SWAT indicates the potential for real-time flood forecast application of the model in Indian watersheds and points to the need for development of better model input data sets which are critical for accurate real-time flood forecasting. In modified SWAT, capability of event modelling has been introduced. Subroutines have been modified to capture the final conditions of the catchment at any desired instant. Model is updated on real-time basis after each time step. Calibration of SWAT model was done with the help of daily simulated results and available measured data of year 2004. Calibration was reasonable with Nash-Sutcliffe efficiency coefficient EF of 0.84 which indicates that simulated values are reliable. Validation of the modified SWAT model was also done using available measured data of year 2005.Nash-Sutcliffe efficiency for validation was found to be 0.7 which is indicative of high predictive power and accuracy of the model. Simulated flow hydrographs generated by SWAT were used as boundary conditions for running unsteady flow analysis by HEC-RAS model for obtaining longitudinal water surface profile and water surface at each cross section.

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Hydrologic Modelling of Kosi and Gandak Basins Using SWAT Model

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Abstract

Hydrologic modelling of the tributaries and main riverof the Ganga river basin is one of the prime activities in developing a short and long term water resources and environmental management plan for this large river. The objective of this modelling is to predict monthly and annual water availability at different reaches of the tributaries and main river Gangas. The northern tributaries in Bihar such as Gandak, Burhi-Gandak and Kosi basins support about 40% of the low season flow in the Ganga river, not only that, they are causing floods annually. Being the major tributaries of the river in Bihar state, the Gandak and Kosibasins covering about 42,604 and 83,443km^2 respectively, are located consequently on the north-western and north-eastern parts of the state.For Ganga River Basin Environment Management Plan (GRBEMP), hydrologic data at the different tributary level of Ganga river is essential. However, there is no reliable observed discharge time series available for these two tributaries. Contemplating this fact, the Soil and Water Assessment Tool (SWAT) model has been considered for this prediction. The geo-spatial input data like Digital Elevation Model (DEM), Soil, and Land Use and Land Cover of different spatial resolutions have been incorporated into the modelling framework. The gridded daily rainfall and temperature data of 0.25° resolution have been used in the modelling setup. The model was simulated at the daily time scale for a period of 46 years (1961-2006). The simulated discharge data were used to estimate annual water yield, annual peak discharge, monthly discharge and their flow duration curves. The estimated quantities are compared with the respective observed flow statistics available in the Kosi and Gandak basins. The comparison shows that the estimated flow duration curves of annual water yield of these two basins closely match with the observed flow duration curves. The percentage distribution of monthly estimated discharge follows that of the observed, but there is a significant deviation between them in the pre-monsoon low months. In the case of the annual peak discharge, the SWAT model predicted an over-estimationof more than 100% for these two basins. In this study, it has been demonstrated that the SWAT model with available geospatial dataset can predict monsoon and post-monsoon monthly discharges in a large river, showing the variation of annual water yield.

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Session-III

Glacier and Snow Melt Modeling Using SWAT: Ganga Basin Case Study

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Abstract

The River Ganga has its origin in the western Himalayas surrounded by considerable snow fields / glaciers. From the snouts of these glaciers the principal head stream of the Ganga originates. The contribution of the snowmelt runoff in the Himalayan rivers is significant. The estimation of average contribution of snowmelt runoff is required for water resources development of the region. Soil and Water Assessment Tool (SWAT) model has been used to determine the snow contribution to stream runoff in the Ganga river basin. The model is calibrated for parameters of snowmelt and results are verified at a few Global Runoff Data Centre (GRDC) gauge sites. In the present study, due the absence of any reliable data on snow depths SWAT model simulation have been used to examine the effects of parameterising snow sub-model using temperature and precipitation lapse rate (TLAPS and PLAPS), elevation bands, and snowfall and snowmelt parameters by comparing simulated stream flow with measured stream flow. First level of simulation produced correlation coefficient ranging from 0•7 to 0•85. Simulation of stream flow, improved by using 10 elevation bands, -6.5oC/km TLAPS and 200 mm/km PLAPS with correlation coefficient of 0•95 and Nash - Sutcliffe model efficiency coefficient of 0•83 at Narayanghat gauge site. Sensitivity Analysis was also performed using SWAT-CUP on parameters of snowmelt to identify the most sensitive parameter influencing snowmelt process.

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Calibration and Validation of QUAL2E Model on the Delhi Stretch of the River Yamuna, India

D.L. Parmar, Ashok K. Keshari

Abstract

The QUAL2E is one of the most popular water quality models used for the purpose of simulation and wasteload allocation studies. However, the applicability of this model for different climate conditions needs to be tested to have accurate prediction by the model. Calibration is one of the most important steps of modeling studies wherein the exact value of reaction parameters to be used in a model is estimated using trail and error method so as to have accurate prediction by the model. In this study, Calibration and Validation of the QUAL2E simulation model has been carried out for the Delhi stretch of river Yamuna, India to find the most sensitive reaction coefficients, namely, the deoxygenration coefficient (K1) and reaeration coefficient (K2). The Calibration was accomplished by adjustment of model coefficients using trail and error method, until the best goodness of fit between predicted and observed data is achieved. The model was calibrated to the observed water quality conditions (based on average conditions of March-June 2002) by adjusting parameters that control the water quality in the study stretch. The model was calibrated with the goal of minimizing the error for BOD, DO and temperature. After calibration, the model was applied to February 2003 survey data for the validation. The performance of the model was evaluated in terms of Coefficient of correlation (R2) and index of agreement (IOA). Results revealed that values of these performance indicators for both, calibration and validation were found to be varying between 0.7142 to 0.9761 thus indicating satisfactory performance. Once the model is calibrated and validated, and its range of accuracy known and judged to be acceptable, it can be used for simulation of water quality.

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Climate Change Impact Assessment on Indian Water Resources – NATCOM Project

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Abstract

A very exhaustive study was conducted as part of the National Communication (NATCOM) phase II project undertaken by the Ministry of Environment and Forests, Government of India to quantify the impact of the climate change on the water resources of India using hydrological modelling of various river basins of the country. Simulated climate outputs from PRECIS regional climate model for present (1961–1990, BL) near term (2021-2050, MC) and long term (2071-2098, EC) for A1B IPCC SRES socio-economic scenario has been used. The distributed hydrological model Soil and Water Assessment Tool (SWAT) has been used on all the river basins of the country. The study determines the present water availability in space and time without incorporating any man made changes like dams, diversions, etc. The same framework is then used to predict the impact of climate change on the water resources with the assumption that the land use shall not change over time.

While modelling, each river basin has been further subdivided into reasonable sized sub-basins so as to account for spatial variability of inputs under the baseline and GHG scenarios. Detailed analyses have been performed to quantify the possible impacts on account of the climate change including the drought and flood analysis. The analysis has been presented spatially to reveal the implications of GHG scenarios in terms of changes in severity of droughts, intensity of floods, sediment loss and low-flows.

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Assessing Climate Change Impacts on the Water Resources in Pune, India, Using Downscaling and Hydrologic Modeling

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Abstract

Climate change will affect local and regional water resources and is therefore of major concern in current hydrology research. Especially in regions with scarce water resources, high climate sensitivity, and/or dynamic socio-economic development, research on developing suitable adaptation and mitigation strategies is needed. While climate projections are typically available at large spatial scales, decisions on water management are usually made on significantly smaller spatial scales. Thus in order to assess management options, downscaling approaches must be employed to link climate change data with hydrologic models.

Our study aims at (i) testing a new downscaling approach and (ii) analyzing the impact of climate change on the water balance components in the Mula and Mutha Rivers catchment upstream of the city of Pune, India. The downscaling approach is based on representing a future climate scenario by rearranging historically measured data. Our approach provides consistent meteorological input, addresses systematic future changes of temperature and precipitation and avoids bias corrections, which is typically required for precipitation data taken from climate models. We use data from the regional climate model COSMO-CLM. This model is driven by the global climate model ECHAM5 applying IPCC scenario A1B. Using the data from the regional climate model, for every week in the scenario run (2001-2100) the best matching week in terms of temperature and rainfall in a baseline period from 1988 to 2000 was identified. For this baseline period meteorological measurements were available. As input to the hydrologic model (SWAT) meteorological measurements of the respective week identified from the regional climate model data were used. The scenario run and its impacts on the water balance were analyzed using four 20-year periods: 2021-40, 2041-60, 2061-80, and 2081-2100.

Validation of the applied downscaling technique indicates that monthly statistics of the rearranged measured data were in good agreement with the statistics of the measured data during the 13-year baseline period. However, with increasing temperatures it becomes increasingly difficult to find a good match in the baseline period. Impacts on the water balance were analyzed with regard to (i) different spatial scales and (ii) differences in the monthly course for the four future periods.

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Evaluation of Climate Change Impact on Water Resources in Upper Sind River Basin, India Using SWAT Model

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Abstract

The water resources of any river basin are a fundamental source for the economic growth and social development. However, due to high temporal and spatial variability in rainfall, prolonged dry seasons and global environmental changes creates a serious pressure on the water resources. The increasing population growth will lead to significant increase in water demand, particularly, for crops and livestock production in the near future. Nearly all regions of the world are expected to experience a net negative impact of climate change on water resources and freshwater ecosystems (IPCC, 2007). The climate projections over India indicate that temperature rise is likely to be around 3°C and rainfall increase is expected by 10-20 per cent over Central part of India by the end of this century (IPCC, 2009). Such increases will affect water availability for use by the different water sectors, particularly, agriculture with serious implications for many livelihoods. The Soil and Water Assessment Tool (SWAT) model is applied to simulate the water resources of the Sind river basin and to evaluate the impact of future climate change. The future annual discharge, surface runoff and baseflow in the basin increases over the present as a result of future climate change and the annual coefficient of variation are also high. However, water resources in the basin will be less reliable in the future and more extreme events (floods and droughts) can be expected.

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Assessment of Surface Water Yield Using SWAT Hydrological Model – Case Study of the Shipra Basin

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Abstract

The Shipra, also known as the Kshipra, is a river of religious importance in Madhya Pradesh state of central India. The river rises in the Kakri Bardi hills of Vindhya Range, north of Dhar, and flows south across the Malwa Plateau to join the Chambal River. Its total length is 195km long, out of which 93km flow through Ujjain and its estimated drainage area is about 562,110 ha.

Estimation of mean runoff is required for water resource development of the region. Soil and Water Assessment Tool (SWAT) has been used to assess water yield for various sub-catchments of Shipra catchment. The model is calibrated using observed monthly values at selected river gauging sites for which sufficient data is available. Sensitivity Analysis was performed using SWAT-CUP on calibrated parameters to identify most sensitive parameters. Validation is performed at Ujjain and Mahidpur gauging sites which have no upstream interventions. The simulation at monthly level compares reasonably well with the observed monthly flows. The R2 and Coefficient of efficiency are above literature acceptable values and range from 0.79 to 0.82 and 0.45 to 0.82 respectively for various sub-catchments.

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Modeling Runoff Response to Changing Land Cover in Penganga Subwatershed, Maharashtra

Abira Dutta Roy, S.Sreekesh

Abstract

Rainfall-runoff relationships within a watershed are a consequence of the interplay of many hydro-metrological factors, driven primarily by the interaction of climatic variables, land use land cover, slope and soils. Surface runoff occurs when the land surface is no longer competent to absorb rainwater, or remove it through the processes of transpiration, infiltration, and sub-surface runoff. Here the land use land cover, vegetation type and various other anthropogenic interventions play a major role in determining the amount, time and rate of runoff generation. This paper evaluates the runoff response to changing land use and land cover in Penganga subwatershed. The study made use of SWAT to model the runoff generation under different land use and cover conditions. The study assumed the normal climatic conditions. The climatic normals were estimated by averaging 37years of data for the period 1975-2011. The digital satellite images of 1976 (Landsat MSS), 1989 (Landsat TM), 1999 (Landsat TM) and 2011(IRS P6 LISS III) were analyzed to identify the land use land cover changes using the standard image classification techniques. The image analysis revealed that a large number of minor, medium and major hydrological structures were constructed during these three decades under study. This has resulted in the intensification of agriculture during post monsoon and summer months. Besides the area that was not cultivated earlier were also brought under agriculture due to the availability of water either from surface or groundwater sources. The modeling of runoff response with SWAT clearly depicted the change in runoff regime with a change in land cover conditions in this watershed. In general, the model output showed an augmented runoff in the winter and summer months.

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Efficiency of Snowmelt Modelling Approaches in Watershed Models

Anand Verdhen, B. R. Chahar

Abstract

Almost all watershed models contain snowmelt-computing option. SWAT has wide range of applicability in geospatial environment. Modelling approach consists of temperature index (in HBV-ETH, STORM, SRM, HEC-HMC & SWAT), snowmelt energy balance (in LEAVESLY, HSP, DHSVM, TOPMODEL & SHE), in combination of both (in HEC-HMC, SRM, TANK & UBC), or multiple regression and other (USBR, SSARR, NWSRFS models). Poor performance of model for the snow-receiving watershed is considered due to uncertainty in simulation and predictability efficiency of snowmelt subroutine. Snow and ice dominated watershed is simulated well by estimating the parameter and coefficients but model fails to predict as temperature index approach is affected by changes in geographical, anthropological and climate scenario, while energy budget application is restricted due to required multiple measured variables and at the same time mixed approach faces the problem of duplicity. Also there is problem of ground observation in remote cryonic zones, which invites attention to predict the climate variables for the higher elevation. Advent and advancement in geographical information system and satellite data for the spatial distribution of the information the desired level of accuracy are yet to be achieved. The paper discusses the snowmelt computation approaches adopted in the above watershed models and verifies the suitability of approach for the Himalayan watershed. It reveals that the evolution of process component's coefficient and processing the input variables on the regional condition of the catchment are prerequisite. The freezing level temperature, critical air temperature, melt rate and temperature lapse rate are determined at weekly mean time scale to represent the melting processes. Deforestation and development have affected the benchmark observation stations to keep the relation with the time series data. However, temperature and snow depth at the base station provides better approximation for the zonal distribution. The paper compares the temporal snowmelt computation results on the weekly data of spring 1983, 2003, and 2009 at station around Lat 32°19'N and Long 77°09'E at 2500 m altitude.

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Session-H3

An European SWAT Soil Database

Pedro Chambel-Leitao

Abstract

In the context of MyWater project (http://mywater-fp7.eu/) and thanks to the availability of European Soil Database (ESDB), a SWAT database of soils was produced for Europe. The soil properties are first gathered at the Soil Typological Unit (STU) level and are then delivered at the Soil Mapping Units (SMU) level, based on the dominant STU. The Soil Geographical Database of Eurasia (SGDBE) provides a harmonised set of soil parameters covering Eurasia and Mediterranean countries at scale 1:1,000,000. It is part of the ESDB, along with the Pedotransfer Rules Database (PTRDB), the Soil Prolfile analytical Database (SPADE). Information in SGDBE is available at the STU level, characterized by attributes specifying the nature and properties of soils. For mapping purposes, the STUs are grouped into SMU since it is not possible to delineate each STU at the 1:1,000,000 scale. SWAT model resuls presented include results on the application of this soil data base to some Portuguese watersheds: Tâmega and Vouga.

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Estimation of Evapo-transpiration in Sardar Sarovar Command Area Using WEAP

Rina K. Chokshi, Gopal H. Bhatti, H. M. Patel

Abstract

In India, rainfall is scanty and unevenly distributed over space and time. Irrigation is essential to sustain agricultural productivity for growing population. As the irrigation demand is increasing, surface water and ground water resources are limited; the efficient use of irrigation water is prime concern for water managers. To estimate the adequate crop water requirements, evapo-transpiration studies are required. The process of evapo-transpiration is dynamic as it is affected by weather parameters like rainfall, minimum and maximum temperature, relative humidity, sunshine hours etc.; crop parameters like crop type, crop development stage, crop height, methods of irrigation, management and environmental conditions like type of soil, application of fertilizers and evapo-transpiration level difference. Various estimation models have been developed; Penman-Monteith model (P-M model) can reasonably estimate the evapotranspiration. In this study, the P-M model is used to estimate crop water requirement in Region-I of Sardar Sarovar Project.

Region-I of Sardar Sarovar Project has sub humid climate and rainfall is non-uniformly distributed over incidence and region. The quantum of rainfall varies from 875mm to as low as 250mm and rainy days also vary from 10-50 days per year. The soil texture also varies from coarse (loamy sand to sandy loam) to moderately fine (sandy loam, sand, clay loam or silty loam) texture. The crops grown in this region are paddy, wheat, juwar, bajra, tur and other pulses, maize, ground nut, tobacco, cotton, castor, banana, sugarcane etc. in this study, wheat and paddy crops are considered and daily climatological data for the year 2004 and 2005 are used. As the demand for the canal water is growing for the drinking and industrial requirements, to decide the supply of canal water to agricultural area, reasonable estimation of water requirement for prevailing cropping pattern is necessary for better water management. The objective of the present study is to estimate the actual crop evapotranspiration (ETc) of wheat and paddy crops in the study area. Excel program is used for computing ETc using P-M equation and single crop coefficient approach, whereas WEAP is used for computing daily ETc value by dual crop coefficient approach. The WEAP uses MABIA method to compute daily ETc. The estimation of ETc by both these methods is further used to evolve irrigation scheduling strategy. The application of WEAP software can be further extended to study area under conjunctive use of surface water and ground water.

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Application SWAT Model in Runoff Simulation of DMIP 2 Watersheds

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Abstract

Developments in computer technology have revolutionized the study of hydrologic systems and water resources management. Several computer-based hydrologic/water quality models have been developed for applications in hydrologic modelling and water resources studies. Distributed parameter models, necessary for basin-scale studies, have large input data requirements. Geographic Information Systems (GIS) and model–GIS interfaces aid the efficient creation of input data files required by such models. One such model available for the water resources professionals is the Soil and Water Assessment Tool (SWAT), a distributed parameter model developed by the United States Department of Agriculture. The objective of the study presented in this paper is to evaluate the surface runoff generation for a well monitored experimental watersheds using ArcSWAT model. The model has been applied to the Distributed Model Intercomparison Project Phase –2 (DMIP2) watersheds. Rainfall data, Land Use (LU)/Land Cover (LC), soil data and Digital Elevation Model (DEM) data of the watersheds has been downloaded from the website of the Hydrology Laboratory (HL) of NOAA's National Weather Service (NWS), USA. The down loaded database has been modified in the GIS environment. The simulation of the runoff in watersheds has been carried out and is compared with observed runoff. The hydrologic behavior of watersheds has been studied based on the simulation results. The present study emphasized the applicability of ArcSWAT models in the watersheds with geospatial database and to understand the hydrologic behavior of the watersheds.

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Estimation of Crop Water Requirement in Mahi Right Bank Canal Command Area

Nidhi Shah, H. M. Patel

Abstract

Water is one of the most important inputs essential for the production of crops. Plants need it continuously during their life and in huge quantities. Both, its shortage and excess affect the growth and development of a plant directly and, consequently, its yield and quality. The paper focuses on analyzing the irrigation water requirement of Wheat, Sugarcane and Paddy crop from year 2001 to 2009 in Mahi Right Bank Canal command area, Gujarat, India. Potential evapotranspiration has been estimated using Penman-Monteith Model (FAO-56). Potential Evapotraspiraiton and crop coefficient for wheat was used for estimating crop water requirement. Effective rainfall and crop water requirement was used for determining irrigation water requirement. Potential evapotranspiration and infiltration is used to determined Net irrigation requirement. Multiplying the cropped area and net irrigation water requirement the volume of water required for crop during the season was estimated. It is observed that, water requirement was more for wheat in water year 2005-2006, for sugarcane in water year 2006-2007 and for paddy in water year 2009. The integration of GIS with crop water requirements estimation model provides quick estimate for irrigation water demand for decision makers.

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Effect of Urbanization on the Mithi River Basin in Mumbai: A Case Study

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Abstract

The rapid population growth and the process of unplanned urbanization have resulted in considerable change in land-uses pattern. Land use modifications associated with urbanization such as the reclamations, removal of vegetation, replacement of previously pervious areas with impervious surfaces and drainage channel alteration and modifications invariably results in changes to the characteristics of the surface runoff hydrograph. Consequently, the hydrologic behavior of a catchment and in turn the stream flow regime undergoes significant change due to large scale urbanizations. The hydrologic changes that urban catchments commonly exhibit are, increased runoff peak, runoff volume and reduced time to peak. Therefore, a better understanding and assessment of land use change impacts on watershed hydrologic process is of great importance for predicting flood potential and the mitigation of hazard, and has become a crucial issue for planning, management, and sustainable development of the watershed drainage system. Many of the highly populated cities in the developing world that are located on the coast, for example Mumbai, are highly susceptible to urban flooding. One of the main reasons cited for this is that these regions receive high-intensity rainfall from the monsoons and being a coastal city, due to tidal effect, even small intensity of rainfall coupled with tidal effect at the same time results in flooding. Mumbai came to a complete halt owing to the unprecedented rainfall of 944.2 mm during the 24 hours starting 08:30 on 26 July 2005 and the city experienced major human as well as economic loss.

In the present study, the Spatio-temporal variations in the urban land use of the Mithi River catchment in Mumbai and its effect on drainage basin are analyzed. The change in land use-land cover (LU-LC) is estimated using toposheet of Survey of India for the year 1966 and satellite images of 2001 and 2009 years and using GIS and Remote sensing techniques. The analysis from toposheet and remote sensing data shows very adverse human induced influences on the Mithi River Course and its catchment. Around 2001, about 37.81 % of mud flat and main river course area has been encroached by unauthorized slum and infrastructural work compared to 1966, reducing the width of river and its coverage. In 2009, about 45.09 % mud flat area and main river course area are covered by buildings, infrastructural work and slum, reducing the river width drastically. From the analysis, it is also found that there is a rise in built up area of Mithi river catchment from 27.00 to 34.49 % between 1966 and 2009, which is the main cause of increase in impervious surface, which in turn increased the runoff resulting in severe flooding during monsoon season.

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Assessment of Future Land Use Change Impacts on Watershed Hydrology for an Urbanizing Watershed in South Korea

Yu, Young Seok

Abstract

The purpose of this study is to evaluate the future land use impact on watershed hydrology for an urbanizing Anseong-Cheon (371.1 km2) in South Korea. Using the past couple of decades of Landsat satellite data, the change of land use were traced. The soil and water assessment tool (SWAT) model was calibrated and validated using daily observed streamflow data with the land use data. The future land uses of 2040s (2020-2059) and 2080s (2060-2099) were predicted using the Conservation of Land Use and its Effects at Small regional extent (CLUE-s) model by establishing logistic regression model for each land use type with driving forces represented by spatial information. The CLUE-s model in this study was applied by combining the driving factors, land use demands, and government policies.By applying the land use predictions to the Soil and Water Assessment Tool (SWAT), the watershed hydrologic components (including evapotranspiration, surface runoff, groundwater recharge, and streamflow) will be evaluated.

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SWAT Check: A Screening Tool to Assist Users in the Identification of Potential Model Application Problems

Mike White , Jeff Arnold, Jimmy Williams

Abstract

The Soil and Water Assessment Tool (SWAT) is a basin scale hydrologic model developed by the US Department of Agriculture's Agricultural Research Service. SWAT's broad applicability, user friendly model interfaces, and automatic calibration software have led to a rapid increase in the number of new users. These advancements also allow less experienced users to conduct SWAT modeling applications. In particular, the use of automated calibration software may produce simulated values that appear appropriate because they adequately mimic measured data used in calibration and validation. Unfortunately, autocalibrated model applications may contain input data errors and/or inappropriate parameter adjustments not readily identified by users or the autocalibration software. Therefore, the objective of this research was to develop a program to assist users in the identification of potential model application problems. The resulting "SWAT Check" is a stand-alone Microsoft Windows® program that: 1) reads selected SWAT output and alert users of values outside the typical range, 2) creates process-based figures for visualization of the appropriateness of output values, including important outputs that are commonly ignored, and 3) detects and alert users of common model application errors. By alerting users to potential model application problems, this software should assist the SWAT community in developing more reliable modeling applications.

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Evaluation of Modified Subsurface Tile Drainage Algorithms in SWAT for the U.S. Upper Mid-West

D. N. Moriasi, P.H. Gowda, J.G. Arnold, D.J. Mulla, S. Ale

Abstract

Abstract:Subsurface tile drains in agricultural systems of the Mid-west U.S. are a major contributor of nitrate loadings to the Mississippi River Basin and cause hypoxic conditions in the northern Gulf of Mexico. Development of strategies to reduce nitrate loadings from these agricultural systems require better understanding of the role of subsurface tile drains on flow. In this study, tile drainage algorithms in the Soil and Water Assessment Tool (SWAT) model were revised and long term (1983-1996) monitoring data on subsurface tile drain flow was used to evaluate the revised model. Measured tile drain flow was obtained from three continuous corn plots located in the University of Minnesota's Agricultural Experiment Station near Waseca, Minnesota. Water, crop, and nutrient management practices on these plots were typical of the Upper Mid-western U.S., where tile drains are essential for agricultural production by draining water from shallow water tables to allow timely tillage and planting operations. Tile flow computations in SWAT are heavily driven by water table depth, which is a function of soil watermovement. However, the traditional method, which computes the retention parameter in SWAT as a function of soil profile water content, generally over predicts runoff in poorly drained soils such as those in the Mid-west U.S. The retention parameter is used to compute daily curve number (CN) for estimating surface runoff. This paper presents 1) modifications made to potential maximum soil moisture retention parameter algorithms in SWAT to account for the effects of tile drainage on the computation of surface runoff using the CN method in poorly drained agricultural watersheds and 2) calibration and validation of the modified SWAT model for subsurface tile drain flow for the Upper Mid-west using long term monitoring data. The retention parameter was increased to account for the effect of tile drainage, which is not accounted for in the CN tables. Predicted annual water budgets, including surface runoff, were similar to those reported for the same study area with the Agricultural Drainage and Pesticide Transport (ADAPT) Model. Comparison of monthly tile drain flows predicted by SWAT to measured data indicated excellent agreement. Monthly calibration and validation Nash□Sutcliffe efficiency (NSE) values of 0.77 and 0.78, respectively, the percent bias (PBIAS) values of -1% and 5%, respectively, and rootmean square error (RMSE) values of 2.9 mm and 2.0 mm, respectively, were obtained with the modified SWAT. The validated revised tile flow algorithms in SWAT will be useful for modeling the impacts of tile drain spacing and depth on nitrate losses.

Coupling Hydrologic and Water allocation Models for Basin Scale Water Resources Management Considering Crop Pattern Changes

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Abstract

To more efficiently use the limited quantity of water in the basin, better methods for control and forecasting of fresh water availability are imperative. Basin-scale management requires advanced forecasts of the availability of water and optimal allocation of water to competitive demands. In this paper we used the Hydrologic Model SWAT to quantify the amount of available water, especially the inflow to reservoir and net irrigation requirements, which is different from constant irrigation demands and is a function of effective rainfall to agricultural fields (crop water requirement – effective rainfall). In addition, we addressed water allocation by integrating the MODSIM river basin network flow model and Particle Swarm Optimization (PSO) algorithm to find the solution for non-linear programming optimization model to maximize farmer income. In the developed PSO-MODSIM model the decision variables are cropped area and irrigation amounts, with reservoir storage as the state variable. As a case study, the model was applied on data from Karkheh reservoir and agricultural lands located in the southern part of the Karkheh River Basin in the semi-arid south-west of Iran. In the example, we assumed three different scenarios of cropping pattern based on previous studies and optimized each one.

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Development of a SWAT-based Soil Productivity Index

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Abstract

The objective was to develop and map a soil productivity index(SPI) for the State of Veracruz, México. The soil variables considered to integrate the SPI were depth (D), texture (T), organic matter content (O), internal drainage (I) and slope (S). Each variablewas divided and mapped into three categories (3C): high, medium and low. Pairs of 3C-maps were successively overlaid: (DT), ((DT)O), ((DTO)I), ((DTOI)S) to yield the final SPI map (DOTIS), which integrates the impact of the five variables in productivity.Soil data was obtained from 829 soil profile description data sets presented along with digital soil maps scale 1:250,000. Land slope was workout from a 90x90m digital elevation model. Productivity was assessed through the dry grain yield of Zea mays.The Soil and Water Assessment Tool (SWAT) model was used to simulate the total biomass and grainyield throughout the 7.18 million hectares of Veracruz. The DOTIS map shows 5.45 0.56 and 0.24Mha with high, medium and low SPI, corresponding to average grain yields of 6.0, 4.4 and 1.4 t ha-1, respectively, which are within the range reported for Veracruz. High SPI is described by deep soil, high organic matter content, slow internal drainage and any soil texture and land slope. Medium SPI is described by medium soil depth, medium to low organic matter content, medium to fast internal drainage and any soil texture and land slope. Low SPI is described by shallow soils and any category of the other variables. SPI mostly depended on soil depth, organic matter content and internal drainage.

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SWAT-based Decision Support System to Assist in Selecting Suitable Agricultural Projects to be Subsidized by a Ministry of Agriculture Agency in the Tropical Southeastern México

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Abstract

The Mexican Ministry of Agriculture in 2007 implemented the Programa del TrópicoHúmedo (PTH), with the aim of promoting the establishment of sixteen highly demanded crops in the tropical southeastern México. Promotion is done through subsidizing the establishment and maintenanceof crop standslocatedinhighly productive areas.The PTH asked INIFAP to develop aninternet,SWAT-based decision support system (DSS) to assist farmers and decision makers in selecting suitable projects. The objective is to describe the developed DSS.The DSS has as a baseline working area the Hydrological Response Units (HRU) created by SWAT, which arethen described by eightvariables: 1) crop yield, 2) soil, 3) Land slope,4) Actual land use, 5) weather data, 6) Crop management technology, 7) crop production costs and 8) cost/benefit relationship.Crop yield was simulated by SWAT, values and/or attributes of variables 2, 3 and 4 were obtained from maps, weather data was taken from1145 weather stations,crop management was designed to attain the highest yield and values of variables 7 and 8 were calculated from local data.The influence of the system is limited to the 215,203 HRU distributed within 5753 sub-basins of 48 watersheds, covering the 50.2 Mhaof southeastern México. The system may be freely accessed via internet; tostartthe consultation,the user only needs to knowthe geographical coordinatesof the farm and the crop name. Information will be automatically displayed and may be used to assist farmers and decision makers to select and manage projects and to allocate subsidy.

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Assessment of Climate Change Impact on Agricultural Water Supply Capacity Using SWAT and MODSIM model

Ahn Sora

Abstract

This study is to evaluate the future climate change impact on agricultural water supply capacity by irrigation facilities viz. reservoir, pumping station, diversion, collecting conduit. For Geum-river basin (9865 km2) in South Korea, the MODSIM (Modified SIMYLD) -a generalized river basin Decision Support System and network flow model developed at Colorado State University designed specifically to meet the growing demands and pressures on river basin management- was established. The study basin includes 2 multipurpose dams, and the municipal, industrial, and agricultural water demand areas and supply facilities were grouped properly and connected to flow. The Soil and Water Assessment Tool (SWAT) was applied to evaluate the inflows to agricultural reservoirs and multipurpose dams. The SWAT was calibrated using the observed dam inflow data. By applying the HadCM3 Special Report on Emissions Scenarios (SRES) A2, A1B, and B1 of the Intergovernmental Panel on Climate Change (IPCC), the change of future agricultural water demand and the corresponding impact on water supply capacity were evaluated by SWAT streamflow routing and MODSIM water balance networks.

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Evaluating the Reduction Effect of Nonpoint Source Pollution Loads from Upland Crop Areas by Rice Straw Cover Using SWAT

Hye-Sun Park, Chung-Gil Jung, Chul-Hee Jang, Seong-Joon Kim

Abstract

This study is to assess how much the non-point source pollution (NPS) loads can be reduced by rice straw surface covering for upland crop cultivation areas using Soil and Water Assessment Tool (SWAT). For a 1.21 km2 small agricultural watershed located in the mid-north of South Korea, the land use of USGS level IV was prepared using QuickBird satellite image. Before the rice straw cover evaluation, the SWAT was calibrated and verified using 9 rainfall events with Nash-Sutcliffe model efficiency of 0.62 ~ 0.78. From the field experiment of rice straw covering, the surface runoff was reduced by 10 % compared to normal surface condition. The cover condition was controlled by the soil saturated hydraulic conductivity in SWAT, and the value of 16.0 mm/hr was found to reduce about 10 % of surface runoff. For this condition, the reduction efficiency of sediment, total nitrogen (T-N), and total phosphorus (T-P) loads were 87.2, 28.5, and 85.1 % respectively. The rice straw cover in upland crop areas was more effective for removing surface runoff dependent loads such as sediment and T-P than T-N.

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Sediment and Nutrient Assessment of Mangrove Swamps Using ArcSWAT: Case study for Bhitarkanika Area

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Abstract

Assessment of sediment and nutrient status is essential for soil and water resources planning and management. Various models have been used and validated for large area applications in this direction at basin and sub basin level. However, not much work has been reported for the estuarine mangrove swamps. Mangrove environment subjected to the freshwater inflow from rivers and runoff from the land side and sea water backflow changes the hydraulic and hydrologic conditions frequently compared to the normal land hydrologic systems. This paper highlights the results of a study carried out for the Bhitarkanika mangrove located at the delta of Brahamani-Baitarni river basins in Odisha state of India. The Bhitarkanika area receives sea water back flow and recession, respectively during the high and low tides of the adjoining Bay of Bengal. Bank erosion during large inflow of water during rainy season is very common. The accessibility of the area offers little scope for in-situ measurements required for model calibration. Thus, use of geospatial modeling with inputs derived from remote sensing data is one of the viable options for such study.

In the present study Arc SWAT hydrologic model was used to understand the runoff, sediment and nutrient yield generation from the Bhitarkanika mangrove area (302.44 km2 area). Satellite remote sensing data was used to generate the land use cover map, drainage network, vegetation density of mangroves. Digital elevation model was used to identify the sub-watersheds within the region. Area was surveyed and measurements were done for sediment, flow, channel characteristics etc. Total 3 sub-watersheds could be delineated. Around 46 per cent area was found under swamp forest, followed by 27.0 per cent under agriculture and 25 per cent under water. Modeling result indicated that sediment generation is highest from agriculture regions (87.5 t/ha) as compared to forest (66.1 t/ha) whereas runoff values range from 516 mm to 650 mm for forest and agriculture regions, respectively. Further, results were analyzed for different sub-watersheds and sub-watershed prioritization was done based on sediment generation and the level of criticalness was assigned to sub-watershed 3 to 1 to 2. The study showed prioritization of sub-areas to adopt management plans to mitigate sediment generation and transportation. However, the transport of sediment from the backflows of water from the sea, which is quite significant during high tide was not accounted in this study due to non-availability of tidal routine in the model. Thus, inclusion of tidal routine in the SWAT model is essential to improve the accuracy of the results for such natural settings.

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Modeling Impacts of Climate Change on Stream Flow and Sediment Yield: Implications for Adaptive Measures on Soil and Water Conservation in North of Iran

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Abstract

Natural earth system confront grand challenges due to climate change. Soil erosion and sediment transport are the key components functioning natural ecosystem. A special report from the Soil and Water Conservation Society indicated that the projected climate changes may increase the overall risk of soil erosion. The amount of change and repercussion is not known for most parts of the world. Iran located in arid and semi-arid part of the world might become one of the most vulnerable regions to climate change. Any change in soil loss and sediment load in this country may have significant implications for water resources development as well as water productivity and food security. A quantitative assessment of climate change impacts on the soil erosion and water resources availability is required to study the potential options in dealing with climate change. The Gorganroud river basin (Golestan Province, Iran) was considered as case study. The Soil and Water Assessment Tool (SWAT) was used to simulate the hydrologic regime in this basin. The SUFI-2 algorithm in the SWAT-CUP program was used for parameter optimization using the daily river discharges and sediment loads. Future climate data of multi-model ensembles were downscaled and fed into hydrologic model to predict the impact on hydrologic regime and sediment load, presenting also the uncertainty resulting from structural differences in the global climate models (GCMs), CO2 emission scenarios and uncertainty due to variations in initial conditions or model parameterizations. This study lay the basis to assess feasibility of protecting the soil and water resources and in an advanced study for water productivity and food security issues in the future.

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Water Consumption and Measures of Conservation in College of Engineering at King Saud University, Saudi Arabia

Abdulmohsen A. AlShaikh, Shamshad Alam and Hamed Alnaimat

Abstract

Water conservation in arid climates can result in efficient utilization of existing water supplies and cost savings. Thus this study was undertaken to understand the various types of water uses and possible measures of conservation in the College of Engineering at King Saud University, Saudi Arabia.

The source of water in the COE is the city water which is supplied by the local municipal body, the average daily water supply to the COE is around 350 m3. COE has various types of water use, but there are only two major uses, namely washbasins and toilets. Toilets use about 50 % of total water consumption while washbasins/faucets use about 30%. The results of measurements of run time as well as amount of water for every run reveals that there is a large variation in flow rates of faucets, however the run time was almost constant for every faucet and toilet. On the basis of results analysis, two possible ways (management measures) to conserve the water were proposed.

The first measure is fixing water discharge rate and run time from washbasin faucets as 0.062 liters /sec and 8-10 sec respectively. The other possible measure is fixing the volume of water as 6 liter against every run (push) for toilets. Findings of this study indicate that the proposed measures can help to achieve water conservation in the college by 24 %, resulting in cost saving by 84000 or 22400 USD SAR per year.

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Are Conflicts in Water Allocation Scale-Dependent? Analysis of Spatial Dependencies of the Demand to Supply Ratio of Water Provisioning in a Mediterranean River Basin

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Abstract

The Mediterranean basin is considered one of the most vulnerable regions to climate change. Scenarios predict an increased frequency of floods and extended droughts, especially in the Iberian Peninsula. These events are likely to widely impact the ecosystem services provided by Iberian river basins, such as water provisioning for agriculture, industry or human consumption. In the meanwhile, water demand for agricultural use is rising, and water scarcity has become an issue in many semiarid regions worldwide, as well as a driver of conflicts in water allocation among both stakeholders and regions. In this study, we examine the balance between the supply and demand of the service water provisioning in a Mediterranean river basin at different spatial scales, aiming to identify the spatial scales at which conflicts arise. Furthermore, this spatial dependency of the ratio supply to demand (S:D ratio) was assessed in different scenarios of climate (wet, mean and dry years) and land use (more or less irrigation agriculture). The Integrated Valuation of Ecosystem Services and Tradeoffs model (InVEST - Kareiva et al., 2011) is a spatially integrated modeling tool that predicts changes in ecosystem services. More than a biophysical model (e.g. SWAT – Arnold et al., 1998), it calculates the economic value of selected services. InVEST was applied on the Ebro catchment (Spain - catchment area is 90,000 km2). Impact of climate and water management contexts was evaluated regarding a water scarcity indicator ratio. Potential conflicts emerging from the 9 scenarios were analyzed at 5 spatial scales. The monetary value of water provisioning was discussed depending on its location and on its purpose within the catchment.

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Roadside Storm Water Management

Sridebi Basu

Abstract

The storm water generated by surface flow from metalled roads during monsoon are generally collected by the designed drainage network and drained to nearest natural water channel. The storm water gets discharged ultimately to the sea hence remain unutilised. But utilisation of storm water in watering plants adaptable to site topography, soil characteristics and climatic condition and also ground water recharge can prevent loss of huge amount of fresh water. The water requirements of these plants are known depending upon the species and density of plantation. The optimal watering of the plants will have less stress in growth and increase the survival probability. The required water for a year shall be stored in the nearest ground water reservoir using injection wells. The same wells shall be used as pumping wells during dry period for drip irrigation along the road. The wells shall be optimally placed based on ground water aquifer, water requirement of plants and pipeline length to have optimal hydraulic loss in transition. The optimal numbers of injection wells shall be operated from a central control room along the roadway to avoid daily manual operation of each pumping well during dry season. The mechanical maintenance cost will increase as the prevailing method is to water the plants once in a day with water carrying vehicles. However, the method mentioned in the paper is more sustainable than present practice.

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Estimation of Sediment Yield in Kiliyar Sub-Watershed Using SWAT Model

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Abstract

Soil erosion is one of the most pressing issues facing on developing countries. Erosion is a natural geomorphic process occurring continually over the earth's surface and it largely depends on topography, vegetation, soil and climatic variables, therefore exhibits spatial variability due to catchment heterogeneity and climatic condition. Poor land use practices and improper management of systems have played a significant role in causing high soil erosion rates, sediment transport and loss of agricultural nutrients. The ArcGIS – SWAT data model is a system of geodatabase that store SWAT geographic, numeric and text input data and results in an organized fashion. The ArcGIS – SWAT interface uses programming objects that conform to the components object model design standard, which facilitate the use of functionality of other window – based applications with ArcGIS – SWAT. SWAT is basically embed into MUSLE (Modified Universal Soil Loss Equation) and it's help full to identify the sediment yield. In this study a physically based watershed model SWAT is applied to the Kiliyar Sub- Watershed for modeling of the hydrology and sediment yield.

The main objective of this study to test the performance and feasibility of SWAT model to examine the influence of topography, land use, soil and climatic condition on stream flows, sediment transport and sediment yield. Some of the reasons behind to choose this study area having a steep slope, exposed rock. The study area chosen was Kiliyar Sub-Watershed and it's cover a total area of the sub watershed is 913.80 Km2.

The Digital Elevation Model represents topographic features and it is used to delineate the whole watershed. Based on that Land Use, Soil Map, metrological data will be entered into the inputs to the model and it's simulate the sediment yield. Stream flows are more sensitive to the hydrological response units definition thresholds than sub basin discretization. Prediction of sediment yield is highly sensitive to sub basin size and slope discretization. Where as the model is simulate the Erosion Prone Potential Rate to their watershed area.

The result of the study will be help the different stakeholders to plan and implement appropriate soil and water conservation management strategies with the sustainable development and it compared sediment yield output from SWAT Model with rainfall data for twelve years. Arc- SWAT will be determine the erosion prone area , based on that we implement the conservation management with effective manner.

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Preliminary Results from Subsurface Hydrological Investigations of Dehgolan Plain (Iran-Kurdistan) using Geophysical Techniques

Payam Sajadi, Amit Singh, Saumitra Mukherjee, Kamran Chapi

Abstract

Dehgolan Basin is located in Kurdistan province and eastern part of Sanandaj City in Iran. This area is known as Dehgolan Basin where eastern part of it is limited by Qorveh-Plain. The whole basin area is estimated to be 2550 square km.

From a geological perspective, Dehgolan plain can be counted as a part of Sanandaj-Sirjan zone which has the same geological history as Iran Central Zone. However, its structure, orientation and layer slope is different and more like similar to Zagros. Yellow coloured Dolomite found in eastern part is intensively crystallised and fractured. Shale and lime sandstone has covered most part of the area with 100m thickness. Quartzite, Shale, Sandstone has been found in southern part with 500m thickness which is very important from aquifer transmissivity point of view.

The need for doing this research is studying conditions for protecting groundwater supplies as a unique source of water for this area. Geoelectrical surveys using the electrical resistivity method were carried out in the Dehgolan-Plain (Kurdistan Province, Iran) to investigate the sub-surface layering and water level. Applying the Schlumberger array, a total of 189 vertical electrical soundings were done. Bore holes information and lithology data were modelled using Rockwork software to generate 3D sections and groundwater flow regime in the area. This was correlated with geological and geomorphological maps of the area and surface topography data. Ground truth surveys with GPS, soil texture analysis, topographic analysis have also been done to generate a GIS database and aid in further correlation with results from remote sensing observations from satellite images.

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Sediment Yield Modelling Using SWAT and Geospatial Technologies

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Abstract

Extensive soil erosion and its attendant ills have already contributed very significantly to the impoverishment of land and people throughout the world. Essential plant nutrients are lost with soil erosion. The soil lost is deposited in various reservoirs, thereby reducing their capacity. Thus, such a situation demands effective planning and implementation of soil and water conservation measures for which water and sediment yield have to be estimated. Several models have been developed and used to assess the problem. In this study, an attempt has been made to use SWAT model, GIS and remotely sensed data for modelling the runoff and sediment yield for Khadakohol watershed in Maharashtra, India. GIS and remotely sensed data are used to develop the required database for the SWAT model. The model's effectiveness has been assessed for its output with default parameters (Prediction in Ungauged Basins) and after scheduling management operations. The model has been calibrated for both runoff and sediment yield for the monsoon months of 2002. Sensitivity analysis, auto and manual calibration have been adopted to get better results. The model has been validated for the monsoon months of 2003 and 2004. The SWAT model, with default parameters has given realistic results, specifically runoff, and the results improved with calibration. It was observed that management parameters have a greater effect on the sediment yield than runoff. Thus, the model has been found to be useful for simulation of runoff and sediment yield even when the calibration data is not available (default parameters) or available for short duration.

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Modeling of Nutrient Losses Prediction from an Agricultural Watershed Using SWAT

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Abstract

The validation ofGIS linkedphysically based continuous time simulationhydrological modelSWA2000 was carried out for nutrient losses predictionfrom an agricultural watershed of Eastern India.IRS-1D LISS-III digital data pertaining to 23rdOctober 2000 was used for landuse/ landcover classification. Eight major landuse/landcover classes namely waterbody, lowland paddy, upland paddy, fallow land, upland crops, settlement, open mixed forest, and wastelandweresegregated through digital image processing. The runoff and sedimentsamples collected at the outlet of the watershed were analyzed fordetermination of nutrients loadings.Model test and validationwere performed sequentially for the sampled events in the monsoon season (June-September) of 2000 and 2001 respectively, for runoff, sedimentand nutrients loss simulation. The observed and simulated mean NO3-N,organic nitrogen, soluble phosphorous, and organic phosphorous were notsignificantly different at 95 % level of confidence as statisticallythe values of t-calculated were less than the t-critical. The values of % deviation (Dv) were found to be -11.451, 14.155, -16.361, 7.383 (in 2000) and -17.057, -11.702, 12.116, 16.388 (in 2001) respectively for NO3-N,organic nitrogen, soluble phosphorous, and organic phosphorous. Theseresults indicated that the model was predicting nutrient lossessatisfactorily. The values of coefficient of determination (r2) of 0.82, 0.84, 0.81, 0.82 (in 2000) and 0.83, 0.82, 0.81, 0.91 (in 2001) respectively for NO3-N,organic nitrogen, soluble phosphorous, and organic phosphorous alsoindicated close agreement between the observed and simulated values ofnutrient losses. Thus, SWAT2000 model accurately simulates nutrientlosses from the study watershed. The simulation results provides a basisfor further scenario evaluation and eventually for recommendation ofimproved management practices for this watershed and other watersheds ofsimilar hydrological conditions.

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Session-J4

Comprehensive Water Stress Indicator

Poonam Ahluwalia

Abstract

Water stress refers to economic, social, or environmental problems caused by unmet water needs. The three major sectors exerting water demand are domestic, agriculture and Industry. Each country / region has a different allocation pattern to each of these sectors depending on the landuse and economy. Although several indices have been developed to indicate water stress affected areas, there is a need to modify these for developing nations like India to effectively take into account practical conditions such as intermittent supply hours and increasing use of grey/ recycled water for non potable uses. The current study builds up on the available indices to propose computation of three sector wise water stress indicators (taking into consideration these practical aspects). The advantage of segregating the index sector wise at the initial stage is to get an indication of the sector wise deficit/ surplus to adequately plan for addressing the issue. For example a surplus in agriculture sector could be utilized preferentially for domestic sector as it is perceived to have more influence on the overall water stress in a region. After determining the individual indicators, an overall indicator can be arrived at after assigning suitable weightages (region specific) to each sector.

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