SWAT 2015
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Book of Abstracts

International Soil & Water Assessment Tool Conference
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CRS4
IDEAS BECOME LIFE

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

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

Contents

Foreword

The organizers of the 2015 International SWAT Conference want to express their thanks to the organizations and individuals involved and their preparation and dedication to coordinate a successful conference. We would also like to thank the Scientific Committee for their support in preparing the conference agenda and allowing for scientists and researchers around the globe to participate and exchange their scientific knowledge at this conference.

A special thank you to the Center for Advanced Studies, Research & Development in Sardinia (CRS4) along with Pierluigi Cau and Fabrizio Murgia for their countless hours and efforts to host the SWAT Community. On behalf of the SWAT Community, we extend our sincere gratitude to you and your university for the kind invitation and welcoming hospitality.

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

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

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Building Capacity in Utilizing NASA Remote Sensing Observations in SWAT for Water Resources and Agricultural Management Applications

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Abstract

The NASA Applied Sciences Program supports technical capacity building activities that enable decision-makers to integrate NASA Earth Science data products into environmental management applications. A project supported by this Program, Applied Remote Sensing Training (ARSET), conducts workshops tailored to end-user needs by working directly with agencies to 1) identify environmental management activities that could benefit from NASA Earth Science data, and 2) conduct webinars and workshops that teach the use of NASA data products and decision-support tools best suited to the identified application area. ARSET provides instruction on the access and interpretation of NASA satellite imagery relevant to water resources, agriculture, and land management. In recent years, ARSET has conducted hands-on training workshops in Latin America; and worldwide for the World Bank and the United States Agency for International Development. The aim of this presentation is to introduce weather, climate, and hydrology parameters based on satellite observations that would be useful as inputs to SWAT and as verification data for SWAT simulations in a variety of applications, particularly in geographical areas with sparse surface-based measurements. In addition, ARSET seeks opportunities to engage the SWAT users community in discussing possibilities of developing joint trainings/applications of using NASA remote sensing data in regional decision support activities.

Keywords

Remote Sensing, Large Scale Applications

Catchment experiences from the UK – ground based and aerial survey methods

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Abstract

APEM ltd. is part of a European consortium of companies called Euro-Med Mapping working across Europe on a wide range of remote sensing projects. As part of our environmentally focused remote sensing work, we have undertaken a number of projects mapping catchments and identifying pollution sources. In discussing catchment experiences from the UK (ground based and aerial survey methods), the presentation covers the following areas:

- Aerial survey methods to capture catchment data on diffuse pollution
- Mapping pesticide and other priority substance inputs to rivers from the air
- Walkover based techniques for catchment management and how they can be combined with aerial surveys
- Links with water quality models
- Interventions methods for catchment improvement
- Landowner/ stakeholder engagement to facilitate change in catchment practices

Comparison of CFSR and WFDEI weather reanalysis precipitation data with data from meteorological stations in Brazil: Application in river discharge modelling of the Tocantins Basin

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Abstract

The acquisition of adequate weather data is the most challenging task when setting up a hydrologic model. While vegetation, soil and topographic information can be newly assessed if not available, weather data are needed as extensive time series. In our study, we analysed CFSR and WFDEI precipitation data in comparison to rain gauges in the Brazilian territory (n = 2027) for the period 1980-2010 to evaluate which weather reanalysis better represented precipitation in Brazil. Further, we used monthly-based interpolations (and historic monthly averages to fill gaps in time series) to further improve the best data set to measured precipitation. We then applied the interpolated precipitation in the river discharge modelling of the Tocantins Basin with the Soil and Water Assessment Tool (SWAT). Both reanalyses showed better statistics for monthly series than for daily and annual series. WFDEI better represented Brazilian precipitation than CFSR with higher coefficient of determination (R^2 = 0.76 vs. 0.50; medians), coefficient of determination multiplied by the coefficient of the regression (bR^2 = 0.70 vs. 0.39) and Nash-Sutcliffe coefficient (NS = 0.72 vs. 0.21), but equal percentages of bias (Pbias = 6.9 vs. 3.4). We applied interpolated WFDEI precipitation data in the hydrologic model of the Tocantins Basin with SWAT using 7 river gauges and 3 reservoirs, with an NS > 0.60} for 6 out of 10 stations (NS = 0.19, 0.38, 0.39 and 0.44 for the other 4 stations). Green water flow increased from South-East (640-840 mm) to North-West (1140-1440 mm), while green water storage increased from South (330-1070 mm) to North (2180-3290 mm). Blue water had a less clear pattern, with lower values in the South and central borders of the basin (20-560 mm) and higher values in the central axis and the North (920-1460 mm). Our analysis suggested that WFDEI was an accurate representation of Brazilian precipitation and allowed for the use of reanalysis weather data instead of observational data in hydrologic modelling.

Keywords

CFSR; WFDEI; weather reanalysis

CEAP 2 – A National Scale Model to Support USDA Conservation Policy and Planning

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Abstract

The Conservation Effect and Assessment Project (CEAP) is a federally mandated effort to quantify the benefit of federally sponsored conservation programs in the US. The first CEAP analysis is nearly concluded, and planning for the next analysis is underway. The next generation analysis, CEAP 2 will include a number of improvements designed to allow broader applicability and more rapid assessments. The resolution of CEAP 2 is approximately 40 times greater, allowing these data to be used at both a national and local level. The development of a library of scenario predictions encompassing a wide variety of potential policies will be developed to allow rapid customized CEAP analysis. Much of the CEAP 2 data is being made available for public web download as soon after development. Export coefficients derived from both CEAP 1 and 2 predictions are being incorporated into web based conservation planning tools. Although CEAP was originally a national assessment effort, the need and utility of CEAP at local levels is increasingly apparent. CEAP 2 is being constructed to allow this broader applicability.

Keywords

Large Scale, National

Hydrological and water resource responses to climate change for a temporary river

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Abstract

In recent decades, changes in hydrological regimes have been recorded in most of the river basins of the Mediterranean region. Anthropogenic impacts and climate changes produced alterations in hydrological processes, riparian, wetland, and aquatic ecosystems which depend on flow regimes for maintaining their structure and composition. Several researchers pointed out that a decrease in rainfall amount produced alterations in hydrological regime such as the timing, magnitude and duration of annual extremes, peak flows, and zero flow days. However, few papers analyzed long term evaluation of water balance and ecosystems modifications due to climate change in Mediterranean temporary rivers. The present paper shows the results of a study which analyzes the potential impacts of future climate scenarios on water balance and flow regime for a temporary river. The aim is to provide ecologists and water resources managers data and information about changes in streamflow components and water availability that can have implications for the river ecosystem, especially in a temporary river. The study area is the Candelaro river basin (2200 km^2), located in Apuglia region (S-E, Italy). We analyzed different climate projections for the far-future (2030-2059) and the current conditions (1980-2009). ECHAM5, a general circulation model was used for rainfall and temperature projections. After the downscaling of climatic data, the Soil and Water Assessment Tool (SWAT) model was used to simulate water balance at basin scale and streamflow in a number of river reaches for all analyzed climatic scenarios. The impact on water balance components was quantified at basin and subbasin level as deviations from baseline (1980-2009). Finally, we assessed the flow regime alterations under changing climate by using the Indicators of Hydrological Alterations (IHA) (The nature Conservancy, 2009).

As a consequence of the reduction in precipitations forecasted for all future scenarios (4-7%), the results of our work show a reduction of total water yield, estimated by the SWAT model in 11-28%, and at the same time, an extension of the period with an absence of flow (zero flow days) and an exacerbation of extreme low flow conditions. All the scenarios also show an increase in mean temperature, which varies between 0.5° and 2.4°C. This will bring to a reduction of snow fall in the mountainous part of the basin and to an increase in potential evapotranspiration (4-4.4%) at yearly basis.

As freshwater ecosystem of temporary rivers is particularly sensitive to changes in habitat, it is expected that climate change will impact aquatic biodiversity through various mechanisms, such as temperature increase, changes in river flow regimes, and change in seasonality of events. Hence, climate change impacts will affect and interact with the Water Framework Directive (WFD) implementation activities at different levels. Based on our results, it is expected that climate change may affect the water body type classification (i.e. a perennial river could be classified as intermittent river in the far future) and the ecological communities in reference sites, as well as other components involved in assessment of ecological status. National classification systems will therefore need to take into account climate change impacts on reference conditions, ecological class boundaries and water body typology. All these aspects have not been sufficiently addressed in temporary rivers until now.

In this context, our work can contribute on the one hand to the scientific understanding of climate change impact on water resources in Mediterranean Basin and on the other hand to provide information to support long-term WFD-based water resources management and planning.

Changing Hydrology under a Changing Climate for a Coastal Plain Watershed

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Abstract

Analysis of climate data from the Little River Experimental Watershed near Tifton, Georgia, in the South Atlantic Coastal Plain of the U.S.A. indicate air temperatures will increase (0.15 to 0.41°C decade^{-1}) along with a slight increase in total annual precipitation in the 21st century. The greatest climatic change may be a shift in precipitation from the winter to the summer months. This shift in precipitation is anticipated to cause changes in hydrologic patterns in area watersheds. The SWAT model was used to examine these climatic shifts and to predict probable shifts in hydrology. Impacts on agriculture throughout the region are expected to be mixed. Increasing air temperatures will likely increase evapotranspiration rates, reducing overall water yields during high temperature months. Shifts in precipitation from winter to summer is anticipated to reduce overall water yields from regional watersheds.

Keywords

Climate Change, Water Balance, Watershed Hydrology

Reducing hydrological budget modeling uncertainty related to climate induced change

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Abstract

The use of atmospheric boundary conditions data coming from climate models to feed tools such as SWAT, arouses a number of issues mostly related to temporal and spatial scale representativeness. Daily precipitation data coming from an atmospheric model are always strongly biased and do not have the necessary spatial resolution to represent realistically the spatial distribution of the precipitation field within the catchment.

The CLIMB project (http://www.climb-fp7.eu), funded by the EU-FP7, address some of these issues with the aim of reducing the uncertainty and quantifying risks related to climate induced changes on the hydrological cycle of Mediterranean basins. Within the project, we developed a methodology of precipitation reconstruction at daily scale using Regional Climate Models (RCM) precipitation data of the EU-FP6 ENSEMBLES project (http://www.ensembles-eu.org/). The method, named QQS, combines the daily translation method, a distribution mapping technique used to establish a relationship between the observed and modeled daily rainfall at the different rainfall percentiles, and the Shackle-shuffling methodology. The daily translation method proved valid in many hydrological studies in reducing uncertainty of the probability distribution function of daily values, but fails, when used alone, to reproduce a realistic spatial correlation of the precipitation field within the catchment

The output of 14 different RCMs have been post-processed for the period 1950-2100, using the QQS methodology, for the Riu Mannu basin located in the southern part of Sardinia (Italy). The resulting data sets have been used to model the hydrological cycle with SWAT for two different periods (REF: 1971 -2000 and Fut 2041 - 2070).

With these forcings from 14 different climatic models, SWAT simulated the hydrological budget of the Riu Mannu basin allowing to quantify uncertainty related to the climate modeling.

Climate change effects in a medium-sized Mediterranean basin using the tRIBS hydrologic model

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Abstract

Mediterranean basins are characterized by high precipitation variability, which presents strong seasonality, large inter-annual fluctuations and spatial variations during single events, and by wide spatial differences of terrain and surface properties. As a consequence, these catchments are often prone to the occurrence of hydro-meteorological extremes, including droughts, storms and floods. Furthermore, many studies based on global and regional climate models agree on the prediction that the Mediterranean area will be most likely affected by climate changes with consequent reduced water availability and intensified hydrologic extremes. In the context of the Climate Induced Changes on the Hydrology of Mediterranean Basins (CLIMB) EU FP7 research project, we use the process-based spatially distributed hydrologic model TIN-based Real time Integrated Basin Simulator (tRIBS) to evaluate the effects of climate change in a medium size basin located in an agricultural area of southern Sardinia, Italy, the Rio Mannu at Monastir basin (473 km2). tRIBS has been calibrated and validated with reasonable accuracy using two statistical downscaling strategies for precipitation and potential evapotranspiration, which have been designed to obtain the required high-resolution input data. The outputs of four climate models, selected as the best performing and bias corrected within the CLIMB project, have been downscaled by the same disaggregation tools and used to force the tRIBS during a reference (1971-2000) and a future (2041-2070) period. The variation in Rio Mannu water resources budget in the future period as compared to the reference one has been assessed analyzing the outputs of the hydrologic simulations. We also investigate the propagation of precipitation extremes into discharge extremes in changing climate conditions fitting the Generalized Extreme Value (GEV) distribution to yearly maxima with a regional approach. Our results confirms what is generally predicted for the Mediterranean area, showing a basin future condition of more water shortages due to both reduced precipitations and increased temperatures. The analyses of extremes reveals (i) high uncertainties in precipitation projections, with GEV parameters differing among climate models, reference and future periods, and time duration, (ii) larger variability in discharge estimates and (iii) importance of both soil properties and topography in the basin response to extreme events. Finally, we performed two simulations forced with coarse and fine precipitation inputs which highlighted the benefit of applying downscaling algorithms to climate model outputs better capturing the small-scale variability of precipitation.

Synergistic effects of climate and land use changes on water flow, nutrient exports and trophic state in a Mediterranean limno-reservoir

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Abstract

Water scarcity and water pollution constitute a big challenge for water managers in the Mediterranean region today and will exacerbate in a projected future warmer world, making a holistic approach for water resources management essential. We used the Soil and Water Assessment Tool (SWAT) model developed for a small Mediterranean catchment and calibrated for hydrology and nutrient transport to check the possible synergistic effects of changes in climate and land use on water flow and nutrient exports. The trophic state of a new kind of waterbody, a limno-reservoir (Pareja Limno-reservoir), created for environmental and recreational purposes in the outlet of the catchment, was also evaluated. Combined climate and land us change scenarios did not demonstrate any significant synergistic effect on hydrology. However, they showed noticeable synergistic effects on nutrients exports, relative to running the scenarios individually. While the impact of fertilization on nitrate export is projected to be reduced with warming in most cases, an additional 13% increase in the total phosphorus export is expected in the worst-case combined scenario compared to the sum of individual scenarios. Our model framework may help water managers to assess and manage how these multiple environmental stressors interact and ultimately affect freshwater ecosystems.

Keywords

Climate change; land use; Mediterranean; synergistic effects; trophic state

Modelling lixiviated nitrate by coupling agro-hydrological (SWAT) and hydro-geological (MARTHE) models: an application to the agricultural Boutonne watershed (SW France)

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Abstract

Non-point source pollution from agricultural practices is of serious concern within the Boutonne watershed, 1,200 km^2 wide located in the southwestern France. National and local stakeholders are concerned and willing to get a global assessment of the water resource and a pertinent decision support for targeting appropriate measures on priority areas for restoring the water quality and complying with the European Water Framework Directive.

The ETBX team of the National Research Institute of Science and Technology for Environment and Agriculture (Irstea) has developed a method for assessing the impact of agriculture on freshwater quality and the help of public decision, whereas the French geological survey (BGRM)-Poitiers specializes in groundwater assessment and monitoring. Thus the "Adour Garonne" basin water agency asked them for a global water assessment, through coupled modeling of the agro-hydrological Soil and Water Assessment Tool (SWAT) model and the fully distributed hydro-geological MARTHE model.

The first step of the Irstea-BRGM collaboration has been to evaluate the external coupling feasibility in terms of time calculations, temporal and spatial processing scales, and to identify the correct SWAT parameters for entering lixiviated nitrate from the HRUs (calculation units) into the MARTHE meshes (km wide).

The second step is to develop a specific interface for internal model coupling so as to simulate on a global SWAT MARTHE application the hydric and nitrogen balance linked to the agricultural landuse.

The ultimate step will be to widen the current modeled area up to the whole Charente watershed (10,000km^2 wide) and to transfer the application to the local stakeholders.

Keywords

SWAT. MARTHE, model coupling, NPS, nitrate, integrated water assessment, aquifers, fresh waters, hydrological balance, nitrogen balance, agricultural practices, water quality

Reflecting the interdependence of land use and hydrology in SWAT modeling studies

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Abstract

Land use changes have a pronounced impact on hydrology, while hydrologic changes affect land use patterns. This interdependence of land use and hydrology calls for integrative modeling approaches. The integration of dynamic land use changes in SWAT has been implemented in SWAT2009 and has been used in a number of studies since. However, this possibility has not been used to consequently integrated land use model results with SWAT. Moreover, SWAT model results are not dynamically integrated into land use models. This study aims at evaluating the potential of coupling SWAT with land use models. To this end, spatially distributed water availability (e.g., mean, minimum, and seasonal water availability) is simulated by SWAT for a meso-scale catchment upstream of Pune, India. These spatially distributed data sets are analyzed with regard to their impact on land use patterns. The analysis provides the basis for a coupled modeling system of land use and hydrology that reflects their interdependence. Such a consistent and hence more realistic simulation of hydrologic and land use changes would be beneficial for many SWAT studies that deal with environmental impact assessment.

Keywords

Land use change, coupled modeling, SWAT, India

Impact of Oil Palm Expansion on Water Yied and Water Quality in Merangin Tembesi Watershed, Jambi Provinces

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Abstract

Over the last decades, South East Area has undergone dramatic land-use changes. Particularly the area of oil palm agriculture has increased, often at the cost of forested land. Indonesia, the world's biggest producer of palm oil has currently 10 million hectares under oil palm cultivation. Due to the increasing global demand of oil as source for food and energy, this development will continue in the future. Current plans of the Indonesian government entail18 million hectares under oil palm cultivation by 2020. Inhabitants in our study area, the Jambi region of Sumatra (Indonesia), believe that forest conversion to oil palm has reduced river water yield and increased nitrate pollution. Based on plot experiments we found that nitrate in surface runoff coming from oil palm plots were very high. Intensive use of an-organic fertilization in oil palm plantation has increased nitrate load in the streams.   According to SWAT simulation model, expansion of oil palm area from 11 to 40% in the entire watershed will increase nitrate loading from 5.8 to 9.7 million kg/month and reduced water yield during dry season about 8 million cubic meters per day.

Keywords

Nitrate loading, oil palm expansion, SWAT model, water yield

Analysis of Flash floods in the Andean highlands

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Abstract

The Andes, which is the longest mountain chain in the world, runs through the western part of South America (between latitudes ~10º N and 53º S). In contrast of its length, it is relative narrow (~200 km). However, at its widest point it is divided into two mountain ranges including the arid to semiarid Altiplano. The Altiplano, with an average altitude of 4000 m a.m.s.l., is besides Tibet the most extensive high plateau on Earth. It is located between the Amazon and Chaco basins to the east and the Atacama Desert influenced by the southeast Pacific anticyclone to the west, along the central portion of the Andes cordillera (Garreaud et al., 2003; Vuille and Keimig, 2004).

The Altiplano wet season is defined by the atmospheric circulation conditions. Over 60% of annual precipitation falls during the summer months (DJF) in association with the South American Monsoon (SAM) and interannual variation is large (e.g. Garreaud, 1999; Lenters and Cook, 1999; Garreaud and Aceituno, 2001; Garreaud et al., 2003). During December and February cool, dry, southeasterly flow is present along at least some portion of the central Andes. During January, warm, moist, northwesterly flow spans the full length of the central Andes, providing abundant moisture and low-level instability (Lenters and Cook, 1999).

The Altiplano climate, topography, and location determine the Lake Titicaca, Desaguadero River, Lake Poopó, and Coipasa Salt Lake (TDPS system) hydrologic formation. Lake Poopó basin area is 23,740 km² and part of it includes Paria sub-basin and Oruro City. The Paria sub-basin area is 925.5 km², and its main river was flooded in January, 2015. The flooding affected 4000 families in both urban and rural areas, where the largest damages occurred in northeastern Oruro City.

From December, 2014, to January, 2015, the runoff was registered in a tributary of Paria River (17°48'53.98"S Lat., 66°59'23.77"W Lon.) and the three main peak flows were recorded. Also, runoff from main tributaries were recorded (17°49'17.72"S Lat., 66°59'31.42"W Lon.). Hydrological recording similarly included climatic data (precipitation, temperature, radiation, wind velocity and direction, and relative humidity).

The unusual flash flood event was caused by an intensive rainfall of 8 h duration. The normal maximum water level in the non-perennial river is a few decimeters only. During the flood event, however, the water level quickly reached 1.36 m covering a large area. The development of the flash flood is analyzed in the paper. The large altitudinal differences in the catchment is a main reason in combination with high rainfall intensities leading to flash floods. Also, the absence of natural vegetation in the upper parts of the catchment leading to minimal

infiltration and resistance to overland flow. A hydrological model was calibrated and validated to further analyze the flash flood event in the typically mountainous region. Model results indicate that a small amount only of overland flow infiltrate and a major part of rainfall contribute to the flash flood. Conceptual model parameters are used to further analyze the occurrence of flash floods in the Andean highlands.

Keywords

Flash flood, hydrological modelling, Andes, Altiplano, highlands, mountain basins

The impact of woody biomass production on the water balance of the North German Lowlands - A hydrological modelling with SWAT

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Abstract

In Germany, broad political support drives the expansion of renewable energies. In 2012, renewable energy represented 12.6% of overall energy consumption (Fachagentur für Nachwachsende Rohstoffe). One-third of this renewable energy is produced by biomass. The increasing demand for renewable energy has led to the implementation of biomass, as an energy source, on agricultural land. In the case of heat production, woody biomass is most commonly used, but conventional forestry methods cannot provide sufficient amounts of timber. To counteract this problem, fast growing tree species like willow and poplar were applied to agricultural land in so-called short rotation coppices (SRC). These crops have a lifecycle of 3 to 5 years before they are harvested.

The first studies on the implementation of SRC (Petzold et al., 2009; Webb et al., 2009) showed a significant impact on the local water balance. The observed effects were a reduced groundwater recharge and reductions to the base flow in small streams. To examine and quantify these consequences, the hydrologic model SWAT was applied to various catchments in the Northern German Plains, providing a water balance model in the AGENT research project. The project focused on regions with a high potential for SRC. To account for the heterogeneous climate and morphogenetic conditions in the North German Plains, six catchment areas were selected (Ems, Aland, Treene, Ücker, Randow and Welse). Ems and Aland represent the Pre-Weichselian glacial landscapes and soil-geographical-complex (Geest), whereas Ücker, Randow and Welse are examples of the young Weichselian glacial landscapes. In this context, the Treene basin acts as a link between these complexes. Ems and Treene have a maritime climate and thus benefit from higher precipitation, whereas Ücker, Randow and Welse represent the continental regions characterized by dryer conditions. In this climatic context, the Aland system represents the link between these different moisture regimes.

The SWAT model was selected for the study because it offers a variety of options for water balance modeling and for the parameterization of land use scenarios. Furthermore, the implemented scenarios benefit from the specific parametrization of vegetation and management used in SRC in Germany. For this purpose, the AGENT project includes studies on plant physiology to determine the water balance parameters of poplar and willow. Two elements are considered for the implemented land use scenarios: the maximum area suitable for SRC from a hydrological point of view and the realistic demand, meaning applicable areas. With this method, it is possible to quantify the hydrological consequences as well as determine ecological boundaries for an implementation of SRC.

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Keywords

Hydrology, water balance, renewable energies, North German Plains

Determining the Effect of Land Use Change on Streamflow Using Soil Water Assessment Tool (SWAT)

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Abstract

The purpose of the study was to assess the effect of land use change on streamflow for the Naro Moru river catchment, Kenya. The catchment land use information was acquired for the years 1984, 2000 and 2010. Satellite images was obtained for the years 1984 and 2010 and processed to derive land use classes. Land use data was obtained directly for the year 2000 from Kenya Soil Survey, Nairobi, Kenya. The Soil Water Assessment Tool (SWAT) model, calibrated and validated to simulate average daily steamflow in month was used to predict streamflow during the period 1992 to 2000 under the different land use practices based on the years 1984, 2000 and 2010. All other input model parameters were kept constant while varying the land use during flow simulation. Between the years 1984 and 2000, the area under natural forest cover increased by 14% while that under agriculture reduced by 21%. The area under grassland during this period was negligible at less than 1%. The simulated average daily stream flow in month decreased by 40% in the period 1984 to 2000. This decrease was attributed to the increase in forest cover. During the period 2000 to 2010, there was a further decrease in simulated average daily streamflow in month by 14% attributed to a further increase in forest cover which may have increased soil infiltration thereby reducing surface flow. There was an increase in land area under agriculture during this period, however a lesser increment compared to that under forest cover. Changes in other land use practices including bushland, bare soil and rock was negligible. Assessment of changes in catchment hydrologic response under changing land use is important in the management of water resources in a watershed.

Keywords

Key words: Land use change, Streamflow simulation, Model calibration and validation.

Assessing the impact of precipitation and temperature on hydrological responses in three small-scale catchments in the Ethiopian Highlands

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Abstract

Knowledge of hydrological responses of small-scale catchments is needed to understand the changes in and the consequences for the availability of blue and green water. In the Ethiopian Highland the annual rainfall–runoff ratio in catchments with unimodal and bimodal rainfall patterns ranges from 0.3 to 0.6 which implies major differences in the amounts of blue water leaving a catchment. In order to understand the differences in these ratios, we assessed the influence of precipitation and temperature on the rainfall–runoff ratio in three small-scale catchments in the Upper Blue Nile Basin. We used the Soil and Water Assessment Tool (SWAT) in combination with the Sequential Uncertainty Fitting program (SUFI-2) to calibrate and validate the model for the three catchments. Then, we simulated three scenarios to compare the catchments and to see their hydrological responses to changes in temperature and precipitation. Results show that the rainfall–runoff ratio reacts disproportionately strongly to precipitation changes due to infiltration-excess processes: a 24% increase in annual precipitation led to an average annual rainfall–runoff ratio that was almost 50% higher. The influences of changing temperature on discharge are mainly due to changing evapotranspiration. An increase in the annual maximum temperature of 42% (+6.8°C) resulted in a decrease in the rainfall-runoff ratio of more than 10%. In a final scenario where we brought all three catchments to the same average annual precipitation and temperature, the difference in the rainfall–runoff ratio was considerably lower than under natural conditions, and the catchments with two rainy seasons generated more blue water than the catchment with one prolonged rainy season.

Simulation of rice paddy systems in SWAT: current methods, improved modified approaches and recommendations for developing a rice paddy simulation module

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Abstract

The Soil and Water Assessment Tool (SWAT) ecohydrological watershed-scale model was initially developed in the early 1990s to simulate the impacts of land use, management systems and climate on hydrology and/or water quality. First adopted in the U.S., the use of the model then spread to Europe and then later to Asia and other regions. The range of applications that SWAT has been applied to have also expanded dramatically, which influenced ongoing model development which has been virtually continuous over the past two decades. A key component of many SWAT applications in Asia is accounting for rice paddy production that is common in some subregions within the continent. However, most of these studies do not provide explicit details of how rice production was simulated in SWAT. Other research has revealed that significant problems occur when trying to represent rice paddy systems in standard versions of SWAT, due to limitations in algorithms based on the runoff curve number approach or the pothole option. In response, key modifications have been made to SWAT in recent studies that have resulted in more accurate representation of rice paddy systems. These developments point to the need for the incorporation of an enhanced rice paddy module within SWAT to better capture rice paddy

hydrological and pollutant dynamics, which would support improved use of the model in Asia and other rice production regions. Subtopics related to simulating rice production in SWAT are discussed as follows: (1) an overview of global rice production, (2) typical approaches and problems in regards to simulating rice production in SWAT, (3) recent code modifications to address deficiencies in replicating rice paddy systems, and (4) recommendations for developing a standard rice paddy module for future SWAT codes.

Keywords

SWAT, Rice Paddies, Potholes, Hydrology, Pollutants, Modified SWAT models

Progresses in developing national scale model for agricultural NPS assessment in South Korea: Phase I – rice paddies

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Abstract

Rice is the predominant staple crop in South Korea. The total area of paddy fields is estimated to be 61 % of the cultivated lands over in 1 million hectares. In Korea, paddy fields are often flooded or semi-flooded during growing seasons between April and September and often serve as sources of water pollution. In this study, we develop national scale APEX model(s) that will be used to assess water consumption and pollutant discharge by rice paddies in South Korea. The Agricultural Policy/Environmental eXtender model is enhanced for simulating biophysical processes in paddy fields under flooding or dry conditions. Environmental effects of paddy managements such as puddling, fertilizer application, trans-planting, and irrigation are assessed by simulating scheduled operations during cropping periods. For modeling the whole country at the field scale, national APEX database is being developed for soils, weather stations, and scheduled agricultural managements including planting/harvesting schedule, fertilizer application amount, and other paddy operations. A total of 337 soil types were compiled and formatted for APEX soil database. Daily weather data including precipitation, min/max temperature, solar radiation, humidity, and wind speed measured at 85 national weather stations for up to 30 years. A case study was conducted using field data in Icheon, Korea on water balance and Nitrogen load for two years.

Keywords

APEX, Rice, Paddy, Nonpoint sources pollution, Water quality, Irrigation

SWAT model improvement for discharge process in paddy fields

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Abstract

Paddy fields is the major land use in Monsoon Asian countries. However, it is difficult to apply hydrological models like SWAT for watershed management, because irrigation water use in paddy fields is too complicated to illustrate hydrological processes. In this research, SWAT2012 was modified to simulate discharge process in paddy fields. First, paddy flooding sub-model was developed to simulate the storage of water, sediment, and nutrient above the soil surface layer. Second, percolation model in SWAT was modified. SWAT does not assume saturated condition in the soil, so when soil water exceeded field capacity, water will quickly percolate to the next soil layer. It is not observed in actual paddy fields. In the modified model, percolation rate is limited lower than the infiltration rate from flooding to soil layers. Third, the irrigation application in SWAT was modified. Rice farmers control irrigation based on the water depth, so flooded water depth was added for the trigger of auto-irrigation operation. In addition, the functions of irrigation from double water resources and sediment and nutrient transfer through irrigation were added in this modification. And last, the puddling operation, which is a common practice in rice cultivation, is assumed to be the tillage operation under the flooded condition in this model. In next step, we apply the modified SWAT to actual watershed and evaluate its performance.

Keywords

Paddy fields, irrigation, drainage, monsoon Asia,

Development of an improved irrigation subroutine in SWAT to simulate the hydrology of rice paddy grown under submerged conditions

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Abstract

Rice paddy is the largest staple food consumed by the people around the world next only to maize. However, among the top three cereals, maize, wheat and rice, together which account for 87% of total food grain production, rice consumes the maximum amount of water to produce a unit weight of grain. Soil Water Assessment Tool (SWAT) is a basin scale, distributed hydrological model commonly used to predict the effect of management decisions on the hydrologic response of watersheds. SWAT is increasingly being used to simulate the sustainability of rice production due to climate change. Hydrologic response is decided by the various components of water balance. In the case of watersheds located in south India as well as in several other tropical countries around the world, paddy is one of the dominant crops controlling the hydrologic response of a watershed. Hence, the suitability of SWAT in replicating the hydrology of paddy fields needs to be verified. Rice paddy fields are subjected to flooding method of irrigation, while the irrigation subroutines in SWAT are developed to simulate crops grown under non flooding conditions. Moreover irrigation is represented well in field scale models, while it is poorly represented within watershed models like SWAT. Reliable simulation of flooding method of irrigation and hydrology of the fields will assist in effective water resources management of rice paddy fields which are one of the major consumers of surface and ground water resources. The current study attempts to modify the irrigation subroutine in SWAT so as to simulate flooded irrigation condition. A field water balance study was conducted on representative fields located within Gadana, a subbasin located in Tamil Nadu (southern part of India) and dominated by rice paddy based irrigation systems. The water balance of irrigated paddy fields simulated with SWAT was compared with the water balance derived by rice paddy based crop growth model named ORYZA. The variation in water levels along with the soil moisture variation predicted by SWAT was evaluated with respect to the estimates derived from ORYZA. The water levels were further validated with field based water balance measurements taken on a daily scale. It was observed that the modified irrigation subroutine was able to simulate irrigation of rice paddy within SWAT in a realistic way compared to the existing method.

Keywords

SWAT, Water balance, Oryza, Irrigation

Inter-comparison and Assimilation of Remote Sensing Evapotranspiration into a Physically Distributed Hydrological model (SWAT), Upper Blue Nile Basin

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Abstract

In the past decade, the scientific communities have been trying to narrow down the gap between the reality and the concept behind the model for reliable management plans and actions. Among these studies, exploration of the major hydrological process, Evapotranspiration taking the leads. In this study, four exemplar remote sensing based energy balance evapotranspiration and a semi-distributed hydrological model were intercompared and assimilated into the SWAT model for the Upper Blue Nile river basin, Ethiopia. This case study has a catchment area exceeding 172,000 km^2 mainly featured with, dominate agricultural land uses followed by forest, seasonally dependent flow pattern and unlikely gauged.

A mean monthly, spatially explicit remote sensing ET products; ALEXI, CMRSET, MODIS & SSEBop were used from 2002 – 2011. Which were downscaled to the case study of regional & global scale Energy balance models. These products vary from reference Evapotranspiration based analysis to a stratified land surface reflectance quantification. On the other hand, a physically distributed water balance model, SWAT built with a unique combination of dominant land use, soil and slope. Which were calibrated and validated using WATCH forcing climate data from 1975 to 1985 and 1986 to 1995 respectively at daily, monthly and annual time scale were considered.

In this study, we tried to assess the seasonal Evapotranspiration dynamics for all remote sensing products, the ensemble and SWAT model at different land use classes and Subbasin clusters. Lastly, spatially and temporally distributed, remote sensing ET integrated into the SWAT model which is one of the nobility of this paper. All products including SWAT model, actual evapotranspiration is less than and/or equal with Hargreaves's method reference Evapotranspiration (ETo) which explicitly compiles with the region's seasonal patterns. Basin and Subbasin scale analysis shows, a significant & noticeable difference observed between the different evapotranspiration product in agricultural and forest dominated land use classes. Although, from the long term seasonal intercomparison, ET values vary from 0 to 250% among these products.

In relation to SWAT model, MODIS product systematically underestimates in most of the cases, while, the other products overestimate at the wet, less likely in dry seasons which clearly varies at different land use classes. Actual evapotranspiration were extremely underestimated in forested land uses by the water balance model in all the cases, noticeably recorded a maximum of 900%. Furthermore, the fraction of relative bias in reference to SWAT model was computed and incorporated into the SWAT model to account the seasonal and spatial heterogeneity of the catchment.

Keywords

Evapotranspiration, Hydrological model, SWAT, Remote sensing ET, Inter-comparison, Assimilation, Upper Blue Nile.

Brokering as a framework for hydrological model repeatability

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Abstract

Data brokering aims to provide those in the sciences with quick and repeatable access to data that represents physical, biological, and chemical characteristics; specifically to accelerate scientific discovery. Environmental models are useful tools to understand the behavior of hydrological systems. Unfortunately, parameterization of these hydrological models requires many different data, from different sources, and from different disciplines (e.g., atmospheric, geoscience, ecology). In basin scale hydrological modeling, the traditional procedure for model initialization starts with obtaining elevation models, land-use characterizations, soils maps, and weather data. It is often the researcher's past experience with these datasets that determines which datasets will be used in a study, and often newer, or more suitable data products will exist. An added complexity is that various science communities have differing data formats, storage protocols, and manipulation methods, which makes use by a non-native user exceedingly difficult and time consuming. We demonstrate data brokering as a means to address several of these challenges. We present two test case scenarios in which researchers attempt to reproduce hydrological model results using 1) general internet based data gathering techniques, and 2) a scientific data brokering interface. We show that data brokering can increase the efficiency with which data are obtained, models are initialized, and results are analyzed. As an added benefit, it appears brokering can significantly increase the repeatability of a given study.

Keywords

BCube, Brokering, Data Aquisition, Modeling

Development of Soil Model Parameter Repositories
for Modeling in CEAP

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Abstract

Soil parameters are crucial input for the USDA Conservation Effects Assessment Project (CEAP) models, such as SWAT, APEX, and ALMANAC. This presentation describes the development process of hydrology-structured geographic databases storing soil hydraulic, physical, and chemical parameters for these models. The products provide reviewed and continuously extending parameter information in comprehensive packages, which combine informational attributes, mapping features/rasters, and geo-processing functionality with the explicit preservation of the original conceptual links between soil series and composing soil layers.

Keywords

SWAT, APEX, ALMANAC, Soil Database, Modeling

On HRU aggregation and its effect on SWAT model output

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Abstract

Reducing complexity is a necessary evil for computationally efficient watershed models. This applies especially for large-scale applications when combined with comprehensive inverse modeling approaches for model calibration, uncertainty analysis, and/or optimization-based scenario exploration. In SWAT, complexity can be reduced during model setup using the ArcSWAT GIS interface where users can define area thresholds for land use, soil, and slope (in ha or percent of subbasin area) to remove negligibly small HRUs. The HRUs left over are reapportioned to sum up again to 100 %. This way of reducing input data complexity is quickly feasible for SWAT users but at the same time highly subjective and error-prone. The decision for certain thresholds to exclude different landscape information can hardly be made by logical reasoning.

Based on SWAT simulations for two contrasting watersheds, the Central German Saale River Basin and the Upper Amazon River Basin, we will show that HRU aggregation can lead to heavily modified spatial input data (land use, soil, and slope), and that these aggregation errors strongly affect model results (e.g. hydrology, sediments). We will introduce an HRU aggregation analysis tool that can be used for automatically calculating the aggregation error related to thousands of different HRU threshold combinations. With this, it is possible to identify best threshold values based on rational principles, such as the maximum tolerable aggregation error. The tool can serve as a practical guide for every SWAT user to efficiently reduce input data complexity while keeping the related aggregation error, and thus model error, as low as possible.

Keywords

HRU, Average Relative Error of Aggregation, hydrology, Upper Amazon, Saale

Spatial scaling of phosphorus export coefficients and load reductions due to agricultural best management practices

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Abstract

Phosphorus yields (kg ha^{-1} yr^{-1}) from selected land covers, sometimes called export coefficients, tend to get smaller as the area of landscape considered gets larger, because some of the phosphorus mobilized on local fields gets trapped during transport to regional watershed outlets. Phosphorus traps are commonly lowlands including floodplains, wetlands, and especially lakes, which can then become impaired by eutrophication. The Sunrise River watershed in east central Minnesota, USA, has numerous lakes impaired by excess phosphorus. The Sunrise is tributary to the St. Croix River, whose much larger watershed is terminated by Lake St. Croix, also impaired by excess phosphorus. A Soil and Water Assessment Tool (SWAT) model of the Sunrise watershed was constructed to estimate phosphorus yields and load reductions from applying selected best management practices (BMPs). In this study, tilled cropland in rotation with corn, soybeans, and alfalfa had an estimated total phosphorus yield of 2.12 kg ha^{-1} yr^{-1} at the upland field scale ($\sim$0.6 km^2), 1.39 kg ha^{-1} yr^{-1} at the subbasin scale ($\sim$7 km^2), and 0.85 kg ha^{-1} yr^{-1} at the watershed scale (Sunrise River, 991 km^2). These values are consistent with a cropland phosphorus yield of 0.63 kg ha^{-1} yr^{-1} at the major river basin scale (St. Croix River, 20,000 km^2), as estimated by others. Agricultural BMPs, including vegetated filter strips, grassed waterways, replacement of row crops with switchgrass, and reduction of soil-phosphorus concentrations, were predicted to reduce phosphorus loads by 4-20%, with similar percentage reductions for field and watershed spatial scales.

Keywords

best management practices (BMP's); export coefficients; nonpoint source pollution; nutrients; transport and fate; watersheds

Field data-based implementation of land management and terraces on the catchment scale for SWAT in the Three Gorges Region, China

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Abstract

In this study, an innovative method to generate spatially-distributed data sets on land management and terraces based on sparse field data for the steep-sloping Xiangxi catchment in the Three Gorges Region in China is introduced and tested using the eco-hydrological model SWAT. The generation of such data sets is challenging in large catchments with poor data coverage, but at the same time necessary for the development and evaluation of Best Management Practices (BMP) towards a reduction of high inputs of sediment and nutrients in water bodies. The dataset on land management was generated using geo-referenced photos from the field, which were processed in a GIS approach towards a definition of areas with uniform land management within the catchment. The management operations for every crop rotation were implemented based on field interviews with local farmers. Under the premise that the protective potential of terraces against erosion depends mainly on the condition of the terraces, terrace conditions were determined on the subbasin level based on the field observations. To extrapolate the information on the average terrace condition on the whole catchment, a multiple regression approach involving land-use-based and topographic variables was used. The protective potential of different terrace conditions was then reflected in the adjustment of the relevant SWAT parameters. It is hypothesized that the inclusion of land management as well as terraces as BMPs in the eco-hydrological modelling approach are individually as well as combined able to increase the model efficiency regarding streamflow and sediment. The results of the study show that the field data sets on land management and terraces can be used to generate meaningful SWAT input data sets and the model results are plausible. The effect of land management and terraces on streamflow is identified to be rather small. At the same time a strong effect of the inclusion of the terrace dataset regarding the modelling efficiency of sediment yields can be observed, which can be seen as an improvement of the process representation within the model for the Xiangxi catchment. By introducing the new method for the derivation of data sets for land management and terraces based on sparse field data, the study contributes to an improved representation of land management and terraces in eco-hydrological modelling. At the same time the study confirms the importance of the consideration of BMPs in eco-hydrological modelling, especially towards the representation of the dynamics of sediment and sediment-bound agro-chemicals.

Keywords

Land management; terraces; Best Management Practices; Three Gorges Region

A new R-SWAT Decision Making Framework for the Spatial Identification of BMP Related to Freshwater Management

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Abstract

The work presents and illustrates the application of R-SWAT-DM, a new R framework designed for Decision Making (DM), related to the implementation of Best Management Practices (BMPs), for restoring and protecting the good ecological status of freshwater bodies. R-SWAT-DM combines the use of the SWAT watershed model, the spatial representation of BMPs and an economic component. The SWAT model served as the nonpoint source pollution estimator for current conditions (base line) as well as for scenarios with modified agricultural practices (fertilization and irrigation) and PS nutrient concentrations, after considering waste water treatment upgrading. R-SWAT-DM easily communicates with the SWAT and economic model through simple ASCII files and/or wrapper functions for exchanging information. It includes tools, to launch individual or iterative BMPs simulations or search for optimal strategies. The current version integrates the state of the art in mono and multi-objective optimization libraries that were already implemented in R. It also includes advanced plotting, mapping and statistical analysis functionalities to facilitate the interpretation and assessment of the results. We illustrate the application of R-SWAT-DM in one real-world case study for the Upper Danube Basin, for identifying optimal BMP allocation to achieve two objectives: minimize nutrient load exports and the net cost. The success of conservation programs depends to a great extent on the optimal identification of management solutions with respect to the envisaged environmental and economic objectives. This identification is a complex task, especially when considering that costs and efficiency of conservation strategies can change depending on their locations within a basin. The results shows that optimal spatial conservation practices could reduce the nutrients more than 50% while simultaneously provide more net economic value. The results show that optimal allocation of conservation practices could reduce nutrients by more than 50% while simultaneously provide total net income.

Keywords

R, SWAT, Surface Water Modelling, Best Management Practices

Evaluating the impact of implemented BMPs in Richard Chambers Watershed of Texas

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Abstract

Richard Chambers (RC) watershed is located in North-Central Texas and encompasses the drainage areas of Richard and Chambers creeks, tributaries of the upper Trinity River. The watershed contains two reservoirs (Bardwel and Navaro Mils) and other multiple small reservoirs and about 30 ponds which are frequently affected by pollutants such as turbidity, siltation, dissolved oxygen and high nutrient levels. NRCS have initiated by giving $2 million in financial assistance to farmers, ranchers and forest land owners in the watershed to implement various BMPs from 2003 to 2014. Several BMPs such as No till, conservation till, crop rotation, nutrient management plan etc. were implemented in the watershed. A study is being conducted to evalate the effectiveness of implemented BMPs over time using Soil and Water Assessment Tool (SWAT) and will also recommend areas for potential BMP implementation for further reducing pollutants. Results of the impacts of existing BMPs and potential locations for BMPs will be presented.

Keywords

BMPs, SWAT

Assessment of solid load and siltation potential of dams reservoirs in the High Atlas of Marrakech (Morocco) using SWAT Model

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Abstract

Siltation in reservoir dams is one of the major problems facing many dams in the world. According to a report by the International Committee on Large Dams (ICOLD), more than 50,000 large dams exist around the world with a very large storage capacity, exploited for various purposes and most of them are facing siltation problems.

Dams located in the northern flank of the Hight Atlas Mountain (Morocco) face a lot of problem in terms of water management especially dam siltation caused by soil degradation; phenomenon which is becoming more than ever alarming. SWAT (Soil and Water Assessment Tool) a GIS based hydrologic model, was applied at the aim of modeling the N'fis Basin in the southern Tensift watershed to predict sediment yield and runoff and to assess the potential of watershed management in order to understand the higher rate of siltation of Lalla Takerkoust dam.

The performance of the model was evaluated using statistical and graphical methods to evaluate the capability of the model in simulating runoff and sediment yield from the study area.

In terms of modeling, the aim is not just the optimal return of the flow at the outlet but also the most realistic simulation of possible contribution of different reservoirs to flow. The overall capacity to return the flow of a modeling tool (SWAT), in this particular climatic conditions, will be tested initially.

In the N'fis watershed located in the Hight Atlas of Morocco (total surface1707 km^2), daily runoff and sediment event data from 2001-2011 were used in this study; data from 2001-2008 were used for calibration and 2008-2011 for validation. The evaluation for the daily runoff simulation showed that the results were satisfy. For sediment load simulation, the SWAT model performed well in capturing the trend of sediment load, while the model tended to estimate sediment load during the calibration and validation.

The erosive energy was determined using the RUSLE equation then integrated into the SWAT model to determine soil loss at each hydrological response unit (HRU) and in the watershed, this rate was 123 t/ha for an annual rainfall of 553mm.

Keywords

erosion, siltation, HRU, SWAT, remote sensing

Assessing Water Quality Sensitivity to Decadal Climate Variability in the Missouri River Basin based on SWAT Simulations

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Abstract

It is well-known that excessive amounts of nitrogen (N) and phosphorus (P) in rivers and lakes affect water quality (WQ) and cause a wide range of problems, including reduction of oxygen in water, toxic algal bloom, and loss of aquatic life. It is also well-documented that in the United States, among other sources, non-point sources contribute significantly to the N and P entering rivers, particularly by runoff from farmland using fertilizers. Several studies have indicated that in the Missouri river, with the largest river basin in the US as its catchment area, nutrients and suspended sediment concentrations are influenced by a combination of factors including variations in streamflow/runoff and management practices.Our recent study based on multi-decadal (1950-2012) SWAT simulations over 14,000 hydrologic unit areas (HRU) covering the Missouri River Basin (MRB) shows that streamflow and crop yields (winter and spring wheat, and other major crops) over the MRB are significantly influenced by a combination of three decadal climate variability (DCV) phenomena - the Pacific Decadal Oscillation (PDO), the tropical Atlantic sea-surface temperature (SST) gradient variability (TAG for brevity), and the west Pacific warm pool (WPWP) SST variability. For example, SWAT showed about 80% increase in streamflow compared to average during the positive phase of PDO and negative phase of TAG. Similar deficit was found during the opposite phases of PDO and TAG. These SWAT simulations were conducted with fixed management throughout the study period assuming auto-fertilization. Also, auto-irrigation was assumed in the irrigated areas. Based on the results of this study, we hypothesize that while the SWAT simulations consider idealized management conditions, sediments and organic N produced by these simulations in each HRU would show impacts of the streamflow and crop yield changes during the multi-decadal period.

In the present study, we analyze the SWAT-simulated sediments and organic N and examine their relative variations with respect to streamflow and crop yield anomalies over the MRB. Preliminary results indicate that N and P contributions to streamflow in certain parts of MRB show 40-80% deviations from average between positive and negative phases of the PDO. Substantial spatial variations in N and P deviations are also noted. We intend to focus on HRU-level analysis to further understand the spatial variations in the N and P decadal deviations. This study will help understand natural decadal changes in the water quality parameters and potentially can be used to design management practices for various phases of decadal variability.

Keywords

Nutrient, Decadal Climate Variability

Application of a coupled SWAT-BATHTUB model to evaluate phosphorus critical source areas and land management alternatives on the water quality of Lake Prespa, Macedonia

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Abstract

The Lake Prespa watershed, covering portions of Macedonia, Greece, and Albania, is an ecosystem of global significance. The lake has faced serious environmental challenges, including eutrophication, caused primarily by ineffective water use and resource management practices. In order to identify the sources and likely causes of excess nutrients leading to Lake Prespa's water quality challenges, the United Nations Development Program (UNDP) is conducting a study to model Lake Prespa and its watershed using the SWAT and BATHTUB models. The watershed model has been designed to simulate all of the primary land uses within the watershed based on the historical agricultural and land management practices. This historical simulation has identified the critical source areas for phosphorus that are a primary cause for the excess phosphorous leading to the lake's eutrophication problems. Alternative best management practices, designed to reduce phosphorous losses from critical source areas and to capture the phosphorous before entering the lake, have been simulated in SWAT to determine their potential effectiveness at improving the lake water quality. The predicted landscape nutrient loads from SWAT provided the inputs to the BATHTUB lake model to simulate both historical and future lake conditions, before and after adopting the proposed best management practices. The SWAT-BATHTUB modeling results will ultimately be used to develop a planning tool that will help in prioritization of best management practices that will help to meet the water quality goals for Lake Prespa.

Keywords

Lake Prespa, Macedonia, SWAT, BATHTUB, phosphorus

GIS based Distributed Process oriented Soil Erosion Modelling using Modified Morgan-Morgan Finney Model in Indian Region

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Abstract

Soil erosion control is one of the greatest challenges as it poses serious environmental degradation, especially in country like India where rainfall is concentrated in few months of year, large quantity of runoff associated with high amount of soil erosion is well-observed phenomena. Modified MMF model (Morgan and Duzant, 2008) is a simple process based empirical annual soil erosion model, having distinguishing features such as it incorporates effects of vegetation cover on erosion estimates and simulates processes of detachment, transport and deposition separately for clay, silt and sand. This article evaluates the applicability of Modified MMF model in a small watershed (area of about 37 km[2]) called Pathri Rao watershed, located in foot hills of Shivalik ranges near Haridwar, Uttarakhand, India. The model coupled with GIS has been applied in a distributed manner by discretising the watershed into number of homogenous elements. In this study, for simulation of runoff and soil erosion, all the input parameters related to landuse/landcover, soil texture has been estimated from the guide values proposed by Morgan and Duzant, 2008. Simulations were carried out for the year 2005 and found that the model estimated surface runoff and soil erosion compares well with the observed data with an error of 0.88 and 0.15% respectively. Based on the above obtained results, and the results of other large scale studies like (Lilhare et al., 2014), it can be said that the Modified MMF model can be successfully applied in small to larger watersheds. Likewise, based on the successful results obtained elsewhere, simplistic nature, inherent structure and its unique features mentioned above, it can be said that the modified MMF model has huge potential to be incorporated in the watershed management tools like SWAT as an alternative option for soil erosion estimation in watershed management studies.

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Keywords

Modified MMF model, Soil Erosion, Soil loss, Pathri Rao watershed

Model SWAT as an integrated management tool in water catchment Švihov

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Abstract

Švihov dam catchment, the biggest drinking water source in the Czech Republic and Central Europe, has problems with water quality. Švihov dam catchment spreads over 1200 Km2 and supplies over 1.5 million people in the capital city of Prague and the central Bohemia region with drinking water. Due to intensive agriculture and lack of wastewater treatment plants, the water quality is deteriorating. Therefore, some action has to be made. Technological agency of the Czech Republic supported this project which reduces water quality degradation. Trnávka watershed was chosen for study purposes as it occupies ¼ of Švihov dam watershed. Hydrological balance was made with measured data. Point and non-point sources of nutrients were determined by field research and applied into Soil and Water Assessment Tool (SWAT) model. The aim of this study is to reduce eutrophication and propose complex watershed management to improve state of environment in the entire area. Different management practices would reduce nutrient loads into streams and increase water quality which is the key factor in dam eutrophication. This project would bring methodology and systematic approach for integrated management, and can be applied not only for Švihov dam, but also to other watersheds with drinking water supply.

Keywords

SWAT, GIS, watershed management, water quality, eutrophication

Integration and Validation of Remote Sensing derived Interception Storage into distributed Rainfall-Runoff model

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Abstract

The effective protection of wetlands demands knowledge of hydrological processes, which can be appropriately analysed using distributed or semi distributed models. It is eminent that hydrological models for catchments with significant wetland coverage have to focus on wetland-specific issues such as the hydrological response of natural vegetation, i.e. parametrisation and dynamics of vegetation. The widely used parameter for describing vegetation canopy structure in terrestrial ecosystems is the Leaf Area Index (LAI), which is closely related to interception storage capacity. This study focuses on improving the interception storage capacity calculation as function of the actual vegetation status and seasonal dynamics in the hydrological distributed model.

The main objective of the paper is to integrate seasonal LAI estimates, derived from remote sensing, into a hydrological model for the Biebrza lowland catchment with a significant content of riparian wetlands.

Landsat Thematic Mapper images are used to represent the different vegetation stages during the growing season (near LAI minimum and LAI maximum). The relation between LAI and the interception storage capacity is analyzed for the typical plant communities present in the Biebrza River valley. LAI of different plant communities have been measured using the LAI-2000 instrument and a significant relationship between these measurements and Landsat based NDVI was determined (R^2=0.72). We also found significant correlation between experimentally measured interception capacity for plant communities and LAI measurements. The application yields considerable spatio-temporal differences in interception estimates for scenarios using interception calculated based on the new method and the standard one.

Keywords

Interception storage, remote sensing, LAI, distributed modeling

Application of the new grid-based SWAT landscape model in a small mountainous watershed in Germany

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Abstract

In the field of Integrated Water Resources Management (IWRM) eco-hydrologic models have become a more and more important tool. They can be used for the evaluation of best management practices or the identification of critical source areas of sediments, nutrients or pollutants in a watershed. We apply a grid-based version of the new SWAT landscape model to a small ($51km^2$) mountainous watershed in Saxony, Germany. This watershed is dominated by relatively steep slopes and shallow soils. Here lateral, sub-surface flow appears to be the dominating process for discharge generation. The watershed drains into a drinking water reservoir which contributes to the drinking water supply of the greater region Dresden. Therefore land-management practices have direct implications on water quality in the reservoir.

We analyze the ability of the distributed model version to plausibly represent the small scale runoff generation processes in the catchment. Preliminary results of the first calibration attempts for the grid-version in a 100m cell-size show promising results with Nash-Sutcliffe-Efficiencies around 0.42. The results will be compared to the output of the traditional SWAT version 2012 where the best simulations achieved a Nash-Sutcliffe Efficiency of 0.72. Furthermore we analyze the impact of resolution of input data (20m, 50m and 100m grid cell-size) on the spatial representation of surface runoff, lateral flow and evapotranspiration to draw conclusions for the compromise between computational effort, resolution and informational value of the model output.

Applying treated municipal wastewater to a forested catchment: Modelling effects on stream discharge, sediment and nutrient loads

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Abstract

Spray irrigation of treated wastewater (21,000 m^3 d^{-1}) within the Whakarewarewa Forest (193 ha) of Rotorua, New Zealand was envisaged as a solution to eutrophication of Lake Rotorua. Prior to 1991, the treated wastewater was discharged directly to the lake. Over the first six years of wastewater irrigation, nitrate concentrations increased steadily in the Waipa Stream which drains the irrigated area, prompting concern about the transport of nutrients to the Puarenga Stream and Lake Rotorua further downstream. The objective of this study was to investigate wastewater irrigation impacts on in–stream water quality and to examine management alternatives for dealing with the wastewater. We used the Soil and Water Assessment Tool (SWAT) model to simulate the effects of wastewater irrigation on discharge, sediment loads and nutrient loads in the Waipa and Puarenga streams. The model was calibrated over a period of daily irrigation from 2003 to 2010 and validated from 2011 to 2012. A range of statistical metrics indicated that the model performed well with respect to simulations of discharge, suspended sediment, and nitrogen and phosphorus species in the Waipa and Puarenga streams. Simulations were then run for an unirrigated scenario, and for a range of other management options designed to mitigate the current impacts of wastewater irrigation, including changes in the area and frequency of irrigation. Simulations indicated that nutrient concentrations in the Waipa and Puarenga streams would return to pre–irrigation levels over approximately one year once the wastewater irrigation was removed. Strategies to mitigate nitrate and dissolved reactive phosphorus leaching were shown to include: increasing irrigation areas; avoiding irrigation during high rainfall, and; changing irrigation frequency. The use of the SWAT model to predict nutrient delivery to Lake Rotorua may assist with future decisions about how to manage the treated wastewater.

Keywords

Wastewater irrigation; forestry; management schedules; hourly routing; water quality; Lake Rotorua

Climate change impacts in a Brazilian semiarid catchment: forecasts, and management perspectives using SWAT model

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Abstract

Brazilian semiarid presents nowadays high water scarcity conditions, with limited water availability for multiple uses. Climate change scenarios for the region indicate enhancement of water limitations, pointing out the relevance of water resources management and environmental protection. Field monitoring and modeling at the headwaters of semiarid watersheds can be critical to hydrological processes understanding and to integrated management of water resources, mainly in climate change scenarios with extreme events. The objective of this work was to evaluate runoff variation and potential evapotranspiration changes in semiarid watershed using the SWAT model with climate change scenarios. The watershed in study is located in the Brazilian semiarid. The Mimoso River Basin is part of the Ipanema River Basin, which is a tributary of the São Francisco River. The Mimoso river basin has 124 km² of area. Land use is the basin is mainly agricultural with family farming. For this work climate change data for SWAT (CMIP3) were adopted, from the SWAT website. Rainfall and temperature scenarios for periods of 2046-2064 and 2081-2100 were applied. Hydrological analysis were performed both for wet and dry seasons. SWAT model simulations highlighted the impacts of climate change scenarios on runoff and groundwater recharge in the basin, and the urgent demand for mitigation practices of its headwaters.

Keywords

Family Farming, Runoff, potential evapotranspiration

Preparing for the future: simulating agricultural practices, hydrology and nutrient exports under future climates

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Abstract

We applied the SWAT model to the River Odense catchment in Denmark to analyze the potential future state of the agricultural production and the aquatic ecosystems in Denmark. The model was used to quantify crop yields, hydrological properties and nutrient exports under near (years 2040-2069) and far (years 2070-2099) future climates. Potential future land use scenarios were generated in collaboration with the agricultural sector, and combined with multiple climate model projections. We generally found that cereal crop yields will decrease, and nutrient exports to waterways increase, under future climates. We also found that the most important sources of uncertainty/variability in the future projections differ when looking at hydrology versus nutrient exports.

Keywords

SWAT, climate change, land use scenarios, uncertainty analysis

Hydrological impact assessment of the Guadalupe River Basin (Mexico) under climate change scenarios.

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Abstract

In northern Mexico, water resources management has become a challenging task, aggravated by the vulnerability of this region to climate change. The semi-arid Guadalupe River Basin is under additional pressure due to wine production and drinking water supply. We have applied the SWAT model to the upper section of this basin to assess the impacts of several climate change scenarios on its water availability. An overall good performance was obtained (daily and monthly NSE values of 0.66 and 0.86 for calibration; 0.52 and 0.76 for validation). Water balance and flow components prediction was satisfactory. However, although peak flows were well represented, the model overestimated discharge during low flow periods. Once evaluated, high and low emissions climate change scenarios were simulated. Noticeable impacts of climate change on river flow were obtained, with runoff reductions around -45% in the short term (2010-2039), but up to -60% in the long term (2070-2099). Main driver seems to be the precipitation reduction, but also an increasing water loss -in percentage- via evapotranspiration. Aquifer recharge is expected to decrease up to -74%, with a consequent reduction of groundwater flow. We also quantified the differentiating impacts during dry, normal and wet years. The latter will be the most affected (annual streamflow reduction up to -72%), especially during winter and spring. On the contrary, a slight runoff increase is expected during dry years, especially during summer. These runoff reductions would suppose a big trouble for a region where pressure on water resources is already very strong. Our model framework provides water managers with an approximation of how climate change may affect water availability, serving as a tool to predict further scenarios.

Keywords

Climate change, hydrological modeling, semi-arid, SWAT, water management

Evaluating the impacts of climate change on streamflow and water resources management: Aharchai River, Iran, case study

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Abstract

Precipitation and temperature predictions using General Circulation Models (GCMs) indicate large changes in terms of vulnerability of water resources systems, such as reservoir dams. Recently in Iran, occurrences of drought phenomena, in conjunction with increasing water demands, i.e. water-per-capita decrease, have intensified the competition for water removal between various water consumers in different watersheds. These problems emphasize the necessity of developing modern methods for water resources planning in order to improve water allocations under severe scarcity constraints

In this paper, a method for managing a surface-water-resources infra-structure, i.e. a reservoir dam, is presented to supply different consumptive and non-consumptive demands located downstream of the reservoir which is based on numerical surface water predictions under various climate change scenarios. The case study is the Sattarkhan dam, located on the Aharchai River in northwest of Iran which has been highlighted as a vulnerable watershed to droughts and floods.

In the present study downscaled climate variables, such as temperatures and rainfall, taken from HADCM3- GCM projections for the next 50 years, are employed in the SWAT- watershed-scale hydrologic model to simulate the future reservoir inflows, taking into account the upstream land use. Finally, the water-decision-making model MODSIM-DSS is applied to evaluate the supply of demands of surface water in the downstream area using the previously-computed reservoir inflow predictions. The results show that this combination of SWAT and MODSIM can be used efficiently as an executive program, supporting managers and planners in water resources authorities to satisfy different stakeholders in a water-scarce basin, as is the study region.

Keywords

Climate Change, Drought, SWAT, Inflow prediction MODSIM, Water allocation, Iran

Effect of fertilizer strategies on the grey water footprint in rain-fed and irrigated agriculture

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Abstract

Reducing the grey water footprint (WF) of crop growing is essential given the increasing water pollution associated with food production and the limited assimilation capacity of fresh water. Fertilizer application can magnify the grey WF per unit of crop as a result of increased nutrient leaching to groundwater and runoff to streams, but can decrease the grey WF and thus water pollution per unit of crop as a result of increased crop yield. This study estimates the effect of different fertilizer strategies on the resultant grey WF per unit of crop in rain-fed and irrigated crop production. The water and nutrient balances of the soil and plant growth at field scale are simulated with the Agricultural Policy and Environmental eXtender (APEX) model. We simulate the effect of different volumes and application strategies of both organic and non-organic fertilizers in potato production under different soils and under wet, normal and dry years in a semi-arid environment (Badajoz, Spain).

Keywords

grey water footprint, soil nutrient balance, soil water balance, leaching, crop growth, APEX

Success and challenges met during the calibration of APEX on large plots

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Abstract

As the APEX model is increasingly considered for the evaluation of agricultural systems, satisfactory performance of APEX on fields is critical. APEX was applied to 16 replicated large plots established in 1991 in Northeast Missouri. Until 2009, each phase of each rotation was represented every year for three cropping systems: mulch-till corn-soybean, no-till corn-soybean, and no-till corn-soybean-wheat. Discharge and water quality were monitored from 1997 to 2002 during the growing season of the corn phase of each rotation. After parameterization of the model for each plot using measured weather, topographic, and soil data, and parameter values derived from another APEX application on similar soils, sensitivity analysis was conducted for all global (PARM file) and selected control parameters. The most sensitive parameters were then optimized using the PAROPT software based on data from one plot per cropping system, and validated based on data from the other plots within the same cropping system. Results showed good simulation of average crop yields. Model performance for runoff was excellent; it was satisfactory for herbicide and dissolved nutrients. However, exceptionally low corn yields caused by drought were overestimated. Similarly, exceptionally high corn yields were underestimated. Additional challenges were encountered when simulating a cover crop inter-seeded between corn rows, causing very low simulated corn yields. Overall, these results confirm the usefulness of APEX to evaluate current cropping systems but highlight the need to better understand drought-related and crop competition processes in order to evaluate the effects of climate change and advanced alternative cropping systems.

Keywords

APEX, conservation practices, crop yield, agricultural system, environmental assessment

Climate Change impact assessment on Mediterranean natural pasture

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Abstract

Grassland ecosystems cover approximately 40% of the earth's terrestrial area. In Italy permanent grassland represent 26.7% of the agricultural area, for a total of 3.4 millions of hectares. Sardinia is the region with the largest area covered by grassland and pasture (693,000 ha), covering areas where the morphology, climate, vegetation and soil made them unsuitable for intensive agricultural use. Despite to its equally important productive an environmental role, it is difficult to study natural pasture resources due to their complexity (spatial fragmentariness, and seasonal and interannual variability) and the close dependence on their utilization and management. To this end, the verification or the development of models should go through a coordinated approach based on specific research that aim to study in detail the multiple sources of environmental variation. Prediction of the available biomass of a pasture is the first step to put in place effective management decisions such as the allocation of daily grazing, conservation of surplus, extra animal feed.

With the aim to explore the possibility to assess the impact of climate change on natural pastures the EPIC model was chosen for this study because of its simplified method used to simulate the crop growth. The crop model calibration was performed using experimental data collected from 1983 to 1988 using the experimental model known as "scheme Corrall" (Corrall and Fenlon, 1978). The collected data included aboveground biomass and farming operation dates like tillage and fertilizer application. Moreover, soil samples were collected to obtain information on the soil characteristics and, weather daily data (including rainfall, minimum and maximum air temperatures), of 6 years referred to the trial were collected by a closer weather station. Considering the seasonal production in autumn and spring, After the calibration process for the above ground biomass, the R^2 value of 0.88, and a RRMSE of 22.42. For the validation the R^2 and RRMSE values were 0.74 and 21.74 respectively. The modeling efficiency and index of agreement were respectively of 0.87 and 0.961for the calibration and 0.64 and 0.892 for the validation dataset. The possible response of the studied system to a change in the climate condition were generated by EPIC on the basis of the following two weather datasets: (a) observed daily maximum and minimum temperature, rainfall and atmospheric CO_2 concentration from 1951 to 2010; (b) near future: a 60-year daily weather dataset generated by WXGEN from the 2001–2010 subset of the recorded weather dataset. The pasture yields show increasing trend in the near future, with average production which results to not be statistically different for α of 0.05 for the two different scenarios. To this day, the results of the simulation can be improved solving some problems in simulating the spring growth rate. We aim to solve this problem improving the calibration with the additional data or modifying the approach used to simulate the grasslands. In order to overcome these difficulties and improve the calibration, future activity will be based on the use of different

dataset related to experiments carried out in different area of Sardinia using the same experimental design (Corrall scheme) or simplified observation of the pastures production.

Keywords

Grassland, biomass production, EPIC model calibration, climate change

Drought induced nitrogen and phosphorus credits in corn/soybean rotations in the Upper Mississippi River Basin

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Abstract

Droughts reduce crop yields, which translate to reduced nutrient uptake or removal from the soil. Under such conditions, it may be possible to credit some of the carryover plant nutrients such as nitrogen (N) and phosphorus (P) towards the next year's crop. The size of the N credit, whether N is derived from applied chemical or manure fertilizers or soybean N fixation, will depend on many factors such as immobilization, leaching and denitrification. Many environmental conditions, including the amount and distribution of winter and spring precipitation also impact the N credit. Phosphorus tends to be less mobile than N; therefore, the P credit is largely driven by the harvested yield level, though P levels may be also be impacted by soil erosion losses and leaching. After a drought many farmers are faced with important N and P management decisions, in particular, estimating how much of the N and P applied in the previous year can be carried over to the next crop, and how to accordingly adjust N and P fertilizer rates. To this end, we will apply the Agricultural Policy Environmental Extender (APEX) model to simulate corn/soybean rotations on 3,703 farm fields within the Upper Mississippi River Basin (UMRB) over a 47-year timescale (1960 – 2001). To identify the drought years during this period, the Standardized Precipitation Index (SPI) will be applied to the generated output databases following which an evaluation of the drought induced N and P credits in corn/soybean rotations will be conducted.

Keywords

Droughts, Nitrogen and Phosphorus Credits, APEX, Upper Mississippi River Basin

Derivation of Crop Parameter Attributes for Cropping Systems Modeling

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Abstract

The suite of models developed at Temple, Texas, ALMANAC, EPIC/APEX and SWAT, all share crop growth models based on the same major processes, but with each have some differences causing differences in simulation outputs. While soils and weather data are usually readily available most countries, it is recommended to obtain field data to determine parameters for new plants or refine parameters for newly released cultivars. Yield data of established plants is invaluable for model calibration and validation. Experimental protocols for deriving plant parameters will be described for a wide range of plant types. These standardized field sampling protocols and the methods for deriving the various crop parameters have been developed and are freely available, and are the subject of this presentation.

A two-step global sensitivity analysis of a SWAT model, using simple screening methods and advanced quantitative methods

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Abstract

SWAT (Soil and Water Assessment Tool) is a physically-based, semi-distributed hydrological simulator, which has been widely used to support alternative watershed management practices in large river basins all over the world. A SWAT model includes a large number of parameters, requiring a model optimization process -i.e. calibration- for their estimation. However, searching for the optimal value of all the parameters is often not feasible. Therefore, a parameter sensitivity analysis can be essential to identify a subset of the most sensitive parameters prior to calibration. Moreover, the sensitivity analysis can support the identification of model processes, parameter values and parameter interaction effects.

This paper presents a two-step approach for a global sensitivity analysis (GSA) of a SWAT model. First, relatively simple screening methods, including the Latin-Hypercube- One-factor-At-a-Time (LH-OAT) algorithm and the regression-based method of SWAT-CUP (SWAT Calibration Uncertainty Procedures), are applied to screen out the influential parameters with a limited number of model evaluations. Next, the identified important parameters are further analyzed to fully characterize the effect of the parameters on the model output, using computational demanding quantitative GSA methods, including the density-based PAWN and the variance-based Sobol' methods. Using this approach, it is possible to optimally benefit from a joint utilization of the techniques. In fact, the non-influential parameters are identified by the screening methods with low cost, while extra information about the sensitive parameters and a more reliable parameter ranking are obtained using the quantitative methods. To illustrate the two-step GSA approach, 26 water quantity related parameters of a SWAT model of the River Zenne (Belgium) are selected to be analysed and ranked.

Keywords

Global sensitivity analysis, SWAT model, Two-step approach, Screening methods, Quantitative methods

Using expert knowledge of the hydrological system to constrain multi-objective calibration of SWAT models

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Abstract

The SWAT model is a helpful tool to predict hydrological processes in a study catchment and their impact on the river discharge at the catchment outlet. For reliable discharge predictions, a precise simulation of hydrological processes is required. Therefore, SWAT has to be calibrated accurately to provide reasonable model results not only for discharge at the watershed outlet, but also for the different water balance components.

We highlight the relevance of expert knowledge about the water balance components in combination with appropriate performance metrics by applying a new evaluation framework to identify calibration runs with a realistic representation of the whole hydrological system to our study area, the Little River Experimental Watershed (LREW) in Georgia (USA). Previous studies of the LREW and rules of thumb based on general hydrologic knowledge were used to define appropriate ranges for the water balance components as constraints for the SWAT simulations. After using the Nash-Sutcliffe Efficiency (NSE) and the percent bias (PBIAS) to identify the best calibration runs with respect to the simulation of discharge, we used the constraints to select the parameter sets that also result in a reasonable simulation of the different water balance components.

Our results show that satisfactory NSE and PBIAS values do not guarantee realistic simulation of water balance components. Several trade-offs between good statistics for discharge simulations at the watershed outlet and reasonable average annual amounts of the water balance components have been found. In general, the optimization of a realistic simulation of water balance components comes at the expense of NSE and PBIAS values. We conclude that the application of NSE and PBIAS is not sufficient to ensure a satisfactory simulation of the whole hydrological system. Therefore, we propose our approach of using expert knowledge during SWAT model calibration to constrain the ranges of water balance components and thereby achieve a meaningful simulation of the entire hydrological system.

Keywords

Calibration, expert knowledge, constraints, water balance

Parameter Transferability against Altered Land Use Dataset on Model Predictions Using SWAT

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Abstract

Over the past two decades, sophisticated process-based watershed simulation models have been developed for improved predictions in hydrologic, sediment and nutrient transport processes. Because of their process-based nature, these models are also suitable to study the environmental impacts caused by human activities such as urbanization and various agricultural practices. One of the major impeding factors to utilize complex watershed models is the stage of initialization in compiling required data which could entail great deal of efforts to manage and process large amount of input data. For some rural or urban regions, alternative information of model inputs may be available and yet the implications of these multitude of data sources on model outputs and predictive uncertainty have not been fully investigated. In this study, three sources of land use/cover data: (i) Mid-Atlantic Regional Earth Science Applications Center (RESAC 2000); (ii) National Land Use Cover Dataset (NLCD 2001); and (iii) State Land Use /Cover Maps (STATE), were implemented to perform model predictions at the Greensboro Watershed, Maryland, USA, using SWAT. In addition, the Alternative Dataset Scheme (ADS) and the Parameter Transferability Scheme (PTS) were also included to conduct associated uncertainty analysis. The results show that model predictions and predictive uncertainty depends on the sources of the dataset. In addition, transferability of model parameters can also be affected considerably.

Keywords

Calibration, land use, land cover, uncertainty

Inter-comparison of Physically Distributed Hydrological Model (SWAT) and Climate Change Impact Investigation on Kleine Nete River Basin, Belgium

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Abstract

This article deals with future climate change impact on surface and ground water flow in Kleine Nete river basin, Belgium. The future climate change is predicted by four SRES (Special Report on Emission Scenarios) climate change scenarios (A1B, A2, B1 and B2) which were downscaled for Belgium. This case study has an area of 581 km^2 with dominant sandy soil, agricultural land-uses and relatively flat slope. A physically distributed hydrological model, SWAT with two distinctive model build up processes (dominant and multiple HRUs') were calibrated from 1992 to 1999 and validated from 2000 to 2002 with a mean daily stream flow data. These were performed to compare and identify which modeling approach better suits in explaining the watershed processes. Both models have a Nash –Sutcliffe efficiency greater than 0.78 for calibration and 0.75 for validation, indicating reasonable performances. However, for small catchments with dominant features and relatively small number of Sub basins; using multiple HRUs' provide a more realistic representation of watershed responses. This has been observed in this case study with less under and overestimations of stream flows. The future climate by 2080 were evaluated using an average stream flow from 1992 to 2002 as a baseline. In high climate scenario, the ground water contribution to stream flow has increased by ±58 % in wet and reduced by ± 43% in dry seasons. On the hand, for low climate scenario a decrease of ± 10% and ±48 % were observed for wet and dry seasons, respectively. In relation to stream flow; for high climate scenario it increased by ± 44 % in wet and reduced with ± 23% in dry seasons, whereas for low climate scenario, the flow is reduced by ± 35 % and ± 44 % for wet and dry seasons, accordingly. All comparisons were made in reference to the baseline period. Hence, the basin will likely experience noticeable flooding, hydrological drought and ground water table fluctuations by the end of the 21st century. Taking into account model uncertainties with careful evaluation; decision makers have to be aware of the possible climate change impacts to formulate mitigation and possible adaptation measures.

Soil information to support environmental modelling and sustainable soil management - within the context of the Global Soil Partnership (GSP) and the International Year of Soils

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Abstract

Soils constitute the foundation of agriculture; healthy soils are the foundation of food production and sustain, directly or indirectly, 95% of the global food production. Soils are not a renewable resource in human time scales and they are fragile. Raising awareness on the importance of soils and making healthy soils a key agenda item in public policy was gained by the endorsement of both the World Soil Day and the International Year of Soils by the United Nations General Assembly. To improve coordination among the different existing initiatives and trigger soil actions at various levels, FAO worked with member countries to launch the Global Soil Partnership (GSP). Two of the five pillars of the GSP are especially related to environmental modelling. Pillar one, promote sustainable management of soil resources for soil protection, conservation and sustainable productivity, and pillar four, enhance the quantity and quality of soil data and information: data collection (generation), analysis, validation, reporting, monitoring and integration with other disciplines. Evidence based decisions and sound soil information are much needed for guiding sustainable soil management. Environmental modelling can play an important role in supporting sustainable soil management. However, there are some limitations. It is important to understand how soil information quality and availability affect environmental modelling in general and watershed modelling in particular. How modelling tools can support sustainable soil management by evaluating the potential impact of different land use scenarios and help decision making process to select optimum options. There is a great opportunity of using modern modelling tools to produce harmonized and good quality soil information to cover areas with no or little soil information, however, there are some constraints. Answering these questions will help us to better manage our limited soil resources that will improve and sustain productivity and ensure food security.

Keywords

Watershed modelling, SWAT, land resources

Launching the Soil–Landscape Estimation and Evaluation Program (SLEEP) to support soil-related environmental modeling

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Abstract

The spatial distribution of soil properties is important for environmental modeling and influences the accuracy of the outputs. The availability of high-resolution soil data is limited by the cost of soil surveys. SLEEP is an ArcGIS-based tool that was developed to predict soil attributes and provide inputs to environmental models such as SWAT. The essential inputs to use the tool are digital elevation model and field observations. In case recent field surveys are not available, previous surveys could be used to derive observations. The tool also allows users to use any layer of information as an input to improve the accuracy, such as satellite images and auxiliary data. The model is menu-driven with many steps to allow quick repetitive analysis. The steps are leading to derive terrain attributes for each pixel and the contributing area. The entire watershed is divided into smaller facets (subdivisions of subwatersheds) and classifies these into groups. Terrain attributes and auxiliary data are used to predict soil attributes using linear regression model. SLEEP utilizes Pedo-transfer functions to provide the spatial distribution of the necessary unmapped soil data needed for environmental modeling. The preliminary application of the model demonstrated the potential of SLEEP to support environmental modeling by providing soil information especially in data-scarce areas. It is anticipated that the widespread use of this public domain tool will help in developing the tool and improving the prediction of soil attributes for various applications.

Keywords

Digital Elevation Model, Terrain analyses, Watershed, SWAT, Linear regression

Food security and water availability in data-poor regions: Towards optimizing land use and ecosystem services

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Abstract

In the Horn of Africa both the economy and the population are growing rapidly, which results in changes in land use. For instance in Ethiopia, forests and grazing land have been converted into crop land, affecting both land degradation and water availability. Conversion of vegetated land to nearly bare agricultural crop land results in less infiltration and more surface runoff. As a result, soil erosion increases and the base flow of rivers lowers, threatening food supply and access to water. Further land degradation may result from anticipated climate change within the next decades, affecting both annual precipitation and its seasonality. Optimizing land use patterns could reduce these effects, by e.g. creating smart arrangements of agricultural fields and natural vegetation. The aim of this project is to study the influence of land use changes under changing precipitation regimes on hydrology and land degradation in the Tikur Woha catchment in Ethiopia Central Rift. A pilot study in this catchment shows some major land use changes between 1986 and 2011 of which the decline in natural forest and the increase in large scale agricultural farming are the most pronounced. Combined with the characteristic erosion rates of the different land use types the results indicate an increase in local erosion rates in the recent 2011 spatial land use distribution compared to 1986. Currently, the work of land-use managers is frustrated by the absence of reliable information on current land-use and land-degradation status. When the land-use managers provide an overview of the required land use to support the population, the spatial distribution can be optimized by taking the topography, hydrology, and land degradation into account. This land-use optimization procedure will be assessed in terms of hydrology and soil erosion magnitude by using the Soil and Water Assessment Tool (SWAT). A combination of multi-temporal remote-sensing data on land use and land cover, existing data sets of meteorology, hydrology and soils, and field data on land degradation will be input into the SWAT model. This modelling will enhance our understanding of the interactions between land-use changes and hydrology and soil erosion. The final product will be a map that shows local land-and-water managers the optimal spatial arrangement of different land use categories. The conference presentation will show an outline of this research combined with the preliminary results of the pilot study. This project will demonstrate a service that will optimize water availability and minimize land degradation while meeting the requirements of a growing population and considering future changes in precipitation patterns.

Keywords

Watershed modelling, spatial optimization land use, remote sensing, data-poor regions

Assessing drought vulnerability of agricultural production systems in the context of agro-hydrological modeling-A case study of Karkheh River Basin

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Abstract

Iran has been affected by frequent droughts in the past and climate change is expected to intensify the situation in the future. Drought can have serious impacts on agricultural and natural water resources systems. Thus, the identification of crop vulnerability to drought is critically important for formulating effective adaptive measures to improve food security. This study investigates the drought vulnerability of wheat, maize and barely in the Karkheh River Basin of Iran in the historical and future climate change context. The crop drought vulnerability index was defined as a function of drought exposure, crop sensitivity and adaptive capacity. The SWAT model of the region was calibrated using the SUFI-2 technique. We extracted the variables required for the evaluation of drought vulnerability. Three levels of vulnerability, low, medium and high, were defined and the bio-physical drivers of vulnerability at each level were identified. The results at subbasin level showed that the vulnerability of different crops varies depending on drought exposure severity, soil characteristics and temperature. Future projection revealed more frequency of high drought vulnerability and less frequency of medium vulnerability for all the three crops. The combined application of the SWAT model with drought vulnerability concept helps better understanding of climate risks to food security. The approach is replicable at different scales to provide a robust planning tool for policy makers.

Keywords

Crop vulnerability, Drought exposure, climate change, SWAT

Intercomparison of regional-scale hydrological models for climate impact assessment in 12 large river basins worldwide

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Abstract

The Inter-Sectoral Impact Model Intercomparison Project (ISI-MIP) is a community-driven modelling effort bringing together impact modellers across sectors and scales to create more consistent and comprehensive projections of the impacts of climate change. This project is aimed in establishing a long-term, systematic, cross-sectoral impact model intercomparison process, including comparison of climate change impacts for multiple sectors using ensemble of climate scenarios and applying global and regional impact models.

An overview and current state of the regional-scale modelling for water sector in ISI-MIP will be given. The scope of the modelling includes twelve models applied to twelve large-scale river basins worldwide (but not every model is applied to every basin). In total, about 90 model applications are done by several collaborating groups. The modelling tools include: ECOMAG, HBV, HYPE, HYMOD, LASCAM, LISFLOOD, mHM, SWAT, SWIM, VIC, VIP and WaterGAP. The river basins included in the study are: the Rhine and Tagus in Europe, the Niger and Blue Nile in Africa, the Ganges, Lena, Upper Yellow and Upper Yangtze in Asia, the MacKenzie, Upper Mississippi and Upper Amazon in America, and the Darling in Australia. The drainage areas range between 67,490 km^2 (Tagus) to 2,460,000 km^2 (Lena). Ten of the basins are modelled with SWIM, and seven – with SWAT.

Data from global and regional datasets are used for the model setup. The model calibration and validation was done using the WATCH climate data for all cases, also checking the representation of high and low percentiles of river discharge. For larger basins, also intermediate gauge stations were included in the calibration. The calibration and validation results, evaluated with the Nash and Sutcliffe efficiency (NSE) and percent bias (PBIAS), are mostly satisfactory. As the next task, climate scenarios from five bias-corrected GCMs are applied, and model outputs intercompared. First results of models evaluation for twelve basins will be presented.

High-resolution Simulations of Decadal Climate Variability Impacts on Water and Crop Yields in the Missouri River Basin with the Soil and Water Assessment Tool (SWAT)

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Abstract

The Missouri River Basin (MRB) is the largest river basin in the U. S. and is one of the most important agricultural regions in the world. Three decadal climate variability (DCV) phenomena - the Pacific Decadal Oscillation (PDO), the tropical Atlantic sea-surface temperature (SST) gradient variability (TAG for brevity), and the west Pacific warm pool (WPWP) SST variability – substantially influence hydro-meteorology in the MRB. We will report on a simulation study with the Soil and Water Assessment Tool (SWAT) to estimate impacts on water availability and crop yields in response to realistic values of the PDO, TAG, and WPWP indices in approximately 14,000 hydrologic unit areas covering the MRB. SWAT, driven by hydro-meteorological anomalies associated with positive and negative phases of the PDO and TAG, indicated major impacts on stream/river flows and yields of major crops such as winter and spring wheat, as much as ±40% of the average in many locations. Impacts of the WPWP index variability were smaller. Consistent with observations during the 1950 to 2012 period, SWAT showed water flow increases of as much as 80% of the average causing very wet periods and very high crop yields when positive phase of the PDO and negative phase of the TAG were superposed. Water flows and crop yields decreased by a similar amount resulting in severe to extreme droughts and significantly lower agricultural production when negative phase of the PDO and positive phase of the TAG superposed. Thus, the combined and cumulative effects of these DCV phenomena on water flows, droughts, wet periods, and yields of major crops in the MRB can be dramatic with important consequences for all water-consuming sectors as well as for national and global food security.

Application of the land use update function in the Soil and Water Assessment Tool (SWAT) for two macro-catchments at the Amazonian agricultural frontier in Brazil

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Abstract

Changes in the hydrological balance and the following degradation of the water ecosystem services due to large scale land use changes are reported from agricultural frontiers all over the world. Traditionally, hydrological models which include vegetation as a part of the hydrological cycle use a fixed distribution of the vegetation cover for the calibration period. We believe that a meaningful calibration - especially when investigating the effect of land use change on the hydrological balance - requires the inclusion of land use change during the calibration period as part of the calibration procedure. Therefore, the work presented here shows the application of the SWAT model land use update function for two contrasting macro-catchments: The upper Rio das Mortes watershed (with 17500 km^2) is located in the Brazilian Cerrado savannah and has experienced rapid and radical deforestation and agricultural intensification in the last 40 years (from natural Cerrado savannah to cattle grazing and intensive corn and soya cropland). The upper Rio Jamanxim watershed (with 34000 km^2) is located in the Amazon rainforest biome and is characterised by still ongoing deforestation for cattle ranging (mainly in the Eastern parts of the catchment). For a meaningful discussion of the effects of land use change versus the effects of climatic variability on the hydrological balance, this work first evaluates the trends and uncertainties connected with the data for model setup, parametrisation, execution and calibration. In the Rio das Mortes catchment, a significant rise in annual runoff could be identified (with a Mann-Kendal test) during the main deforestation in the 1970s. A similar trend cannot be affirmed for the Rio Jamanxim catchment, due to scarce and disrupted discharge data – a typical problem in areas of recent exploitation. Subsequent to this discussion, the calibration periods were chosen to cover periods of rapid land use change with unchanged climatic conditions (1974-1984 in the Rio das Mortes and 1998-2006 for the Rio Jamanxim). The validation was performed for later periods with still ongoing land use change. Especially in the case of the Rio das Mortes, the model can effectively reproduce the rise of annual discharge during the period of most intensive deforestation. For the Rio Jamanxim catchment, due to limited calibration data and a lower degree of overall deforestation, the implementation of land use change in the calibration procedure does not improve the models performance significantly (compared to a steady land use distribution).

Keywords

Land use change, catchment hydrology, data uncertanty, calibration, Amazon agricultural frontier

Impact of current conservation practices on sediment load reduction in the Danube River Basin

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Abstract

The European Water Framework Directive requires River Basin authorities to implement adequate measures to meet water quality targets in freshwater bodies. Integrated watershed models can be used to assess the impact of conservation management practices that are already in place or planned for future action. The aim of this study was to assess the impact of conservation management practices that are already implemented on sediment concentration and load in the Danube River Basin. The Soil and Water Assessment Tool (SWAT) was used for simulating sediment concentrations and loads across the Basin. Spatial information on conservation management practices was derived from European databases and maps. Data comprised agricultural conservation practices (cover crops, residue management, conservation tillage, and green infrastructure), distribution and type of riparian areas, and main barrages along the stream network. These conservation practices were included in the set-up of a SWAT model of the entire Danube Basin. The model was calibrated and validated for streamflow and sediment concentration at multiple gauging stations for the period 1995-2009, following a five year warm-up period. The calibrated model was then employed to assess the relative impact of different management practices on sediment outputs at several key points in the Basin. Practice management data, SWAT modelling of practices, adaptation of SWAT sediment model to large scale application, and calibration and validation results are presented. The impact of current conservation management practices on sediment concentration and loads in the Basin is discussed to provide guidelines for developing future management plans.

Keywords

Danube, sediments, BMPs, Water Framework Directive

Modeling Sediment and Nutrient Loads Input to the Great Lakes and Effects of Conservation Practices on Water Quality

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Abstract

Excess nutrients input to the Great Lakes from its drainage area consisting of agricultural land, urbanized area, forests and municipal and industrial discharges have caused eutrophication in the Lakes and in the surrounding water bodies. Determining the status of sediment and nutrient loads entering each Great Lake, identifying the major sources of these loads, and evaluating the effects of cropland conservation practices on water quality would be useful for planning and prioritizing management efforts. An integrated modeling system consisting of a watershed scale model, Soil and Water Assessment Tool (SWAT), a field-scale model Agricultural Policy Environmental Extender (APEX) were used to model the Great Lakes Basin (GLB). Model inputs representing the basin characteristics and conservation practices were derived from multiple sources. The integrated GLB model was calibrated for water yield, and for streamflow, sediment and nutrients at multiple sites. Then it was used for (1) estimating the sediment and nutrients entering the Lakes, (2) identifying the major sources of the sediment and nutrient loads, and (3) estimating the effects of cropland conservation practices on water quality in each of the Lakes. Model predictions indicated that sediment, nitrogen and phosphorus loads entering Lake Erie, Lake Michigan and Lake Ontario were larger compared to the loads entering Lake Superior and Lake Huron. Cropland was the dominant source of sediment, nitrogen and phosphorus in all lakes except for Lake Superior where the agriculture is less. Urban runoff, point source discharges and grassland were next notable sources of sediment and nutrients. Currently established practices on cropland were predicted to reduce the sediment, nitrogen and phosphorus losses from edge of field within each 8-digit watersheds by 50%, 37% and 36%, respectively. These practices were predicted to reduce the sediment, nitrogen and phosphorus loads entering the entire Great Lakes by 11%, 21%, and 17%, respectively.

Keywords

CEAP, SWAT, APEX, Conservation Practices, Water Quality, Great Lakes, Lake Erie, Phosphorus

SWAT model improvements to simulate bioenergy crops production

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Abstract

The Soil and Water Assessment Tool (SWAT) is widely used to quantify hydrologic and water quality impacts of land use and land management changes. Accurate representation of crop growth and nutrient uptake, simulation of crop residue, and evaluation of energy crop production from specific landscape positions, such as vegetated filter strips, are critical for quantifying ecohydrological impacts of land use change. We have made several improvements in the SWAT model to evaluate impacts of bioenergy feedstock production. Specifically, we have evaluated perennial crop growth representation in SWAT and developed crop-growth parameters for bioenergy candidate perennial grasses *Miscanthus × giganteus* and upland ecotypes of *Panicum virgatum* (switchgrass). Crop growth parameters and their ranges were developed using agronomic and weather data collected at the Purdue University Water Quality Field Station in northwestern Indiana, USA. The perennial crop growth representation by the model was evaluated using a one HRU model developed for the Water Quality Field Station. The model evaluation led to modification of SWAT algorithms to better represent (1) dormancy period below ground biomass and nutrient stored (2) extended plant evapotranspiration for perennial grasses and (3) nutrient update during temperature and water stress periods. We have made similar improvements to evaluate impacts of crop residue removal and utilization of vegetated filter strips from various landscape positions within a watershed. In this presentation we will discuss in details the specific model improvements and resulting impacts on simulation of various bioenergy crop production scenarios at field and watershed scales.

Keywords

Bioenergy crops, miscanthus, switchgrass, crop residue removal, modified SWAT model

Application of improved SWAT model for bioenergy production scenarios in Indiana Watersheds

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Abstract

High yielding perennial grasses such as *Miscanthus* and switchgrass, and crop residues such as corn stover are expected to play a significant role in meeting US biofuel production targets. We used an improved version of the Soil and Water Assessment Tool (SWAT) which has better physiological representation of perennial grass growth and nutrient uptake to forecast impacts of various plausible bioenergy crop production scenarios. The bioenergy scenarios, included: production of *Miscanthus × giganteus* and switchgrass on highly erodible landscape positions, agricultural marginal land areas, and pastures, removal of corn stover at various rates, and combinations of these scenarios. The hydrology and water quality impacts of land use change scenarios were estimated for two watersheds in Midwest USA (1) Wildcat Creek watershed (drainage area of 2,083 km^2) located in north-central Indiana and (2) St. Joseph River watershed (drainage area of 2,809 km^2) located in Indiana, Ohio, and Michigan. The study results indicated improved water quality with perennial grass scenarios compared to current land use and management conditions. Erosion reduction with perennial energy crop production scenarios ranged between 0.2% and 59%. Stream flow at the watershed outlet were reduced between 0.2 and 8% among various bioenergy crop production scenarios. Stover removal scenarios indicated increased erosion compared to baseline condition due reduced soil cover after stover harvest. Stream flow and nitrate loading were reduced with stover removal due to increased soil evaporation and reduced mineralization.

Keywords

Bioenergy crop scenarios, miscanthus, switchgrass, crop residue removal, modified SWAT model, water quality impacts

Assessment of Scenarios for the Boone River Watershed in North Central Iowa

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Abstract

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

Keywords

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

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

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Abstract

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

Keywords

Biofuel cropping systems, Corn Belt region, switchgrass, miscanthus, stover removal, modified SWAT model, nutrient pollution, tile drainage

C-SWAT: A Modified Revision of SWAT Using Consolidated Input Files

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Abstract

In recent years, the Soil and Water Assessment Tool (SWAT) has been implemented broadly in the field of water resources and environmental engineering. Large-scale watershed simulation can be conducted with high resolution input data to provide reliable predictions on hydrologic and nutrients processes. However, the associated burden of great computational efforts has become a raising concern since the current SWAT framework is built upon potentially large number of model input files in both Hydrologic Responses Units (HRUs) and subbasin levels. Computational time increases significantly while a finer resolution SWAT project is settled. In this study, the Consolidated SWAT (C-SWAT) is developed to incorporate HRUs and subbasin data into 13 aggregated files to alleviate the computational burden caused by open/read/write routines. In case study, it has been demonstrated that the runtime of SWAT could be reduced substantially (30%) in the Little Washita River Basin (611 km^2) SWAT project. Users can take advantage of C-SWAT and investigate more challenging topics in the future.

Keywords

SWAT; Consolidated inputs; Auto-calibration; Parallel processing

A macrophyte growth module for the SWAT model - impact of climate change and management on stream ecology

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Abstract

In order to assess how multiple stressors affect stream water quality and ecology at catchment scale under various managment and climate change scenarios, we implemented a macrophyte growth module for the Soil and Water Assessment Tool (SWAT). The macrophyte growth module originates from the INCA-P model (Wade et al., 2002) with an addition of nitrogen stress. Further, a benthic sediment layer and interaction of nutrients between the sediment layer and the water column are implemented. The new modules are validated against macrophyte biomass measurements in several Danish streams. Sensitivity and uncertianty analysis of the new module and scenarios runs will reveal the impact of different stressors (e.g. temperature, nutrient levels and flow rate)on macrophyte growth.

Keywords

SWAT, macrophyte, INCA-P, benthic sediment

Comparison of hydrologic simulation outputs between SWAT2012 and the new modular SWAT code

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Abstract

The current FORTRAN code of SWAT is now being rebuilt to ease development of new modules and model maintenance by incorporating object-oriented programming concepts into defining spatial objects and calculating variables. The new SWAT code, called "modular SWAT code", is also going to include new databases that will be commonly shared by APEX and EPIC. The changes in the codes and database may cause unexpected outcomes like output values being different from those the SWAT2012 code provides. This study compared hydrologic outputs between SWAT2012 and the modular SWAT and investigated the magnitude and significance of the differences found in the outputs. Two versions of SWAT watershed datasets were constructed for a small urban watershed located in Austin, TX, and evaluated for 3-year runoff output at the watershed outlet. The simulation results obtained were compared to quantify the differences, which then tracked through the codes and databases to identify their sources. This study provided insights to the modular code from SWAT users' perspective by comparing it to the current model.

Keywords

SWAT, modular SWAT, modular SWAT code

Karst SWAT hydrological modeling at large and regional scale: the case study of the island of Crete

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Abstract

Karst landscape covers approximately 20% of the earth's surface and provides about 50% of the world's drinking water. In Europe soluble carbonate rocks covers 35% of whole continent and are widespread in particular in Southern, therefore the karst processes are very significant components of the physical geography of the Mediterranean basins. The aim of this study was to apply SWAT model integrated with a karst-flow model in Crete Island (6,669 km[2]) characterized by karst-dominant geomorphology.The Crete SWAT model was developed using DEM of 25 m pixel size subdividing the Island in 352 sub-basins with an average area of 20 km[2]. The combined model (KSWAT) simulated the contribution of the extended karst areas to the discharge of 47 springs. KSWAT was calibrated and validated using a network of 22 monitoring stations and 47 springs respectively for the period 1980-2009 and 1973-2009. The combined model was able to estimate water balance of the whole Crete in different hydrological conditions supporting management decisions regarding public water supply. The KSWAT model was tested also in a large scale version on Crete SWAT model based on DEM 100 m pixel size subdividing the Island in 23 sub-basins with an average area of 127 km[2] in order to assess the applicability of karst-model in the current setup of SWAT in macro regions at pan European scale. The results of this study will be presented and discussed together to provide a SWAT modelling protocol to adopt in karst regions.

Keywords

karst, modelling, SWAT, Mediterranean, water balance, regional scale, large scale,

Application SWAT Model for Hydrological Study of Artificial Recharge through Infiltration Pond in the Water Replenishment, at Jubel Spring Mojokerto Indonesia

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Abstract

The purpose of the hydrological evaluation of the Water Replenishment Program of the Indonesia Urban Water, Sanitation and Hygiene Project (WR IUWASH Project) is to assess the impact of an intervention, infiltration ponds, constructed to replenish aquifers at catchment areas feeding springs to improve the hydrological performance of watersheds. The total catchment area of the Jubel spring is 311.4 ha, located in Claket, Cembor and Nogosari villages. Land cover in catchment Jubel consists of 4 types, forest, 28%, residential, 9.6%, agriculture dry land, 50.8%, and shrub, 11.6%. All infiltration ponds are already built and operating with dimension 2 m x 2m x 2m, the number of infiltration ponds located is 195 units. Infiltration ponds in the recharge area of springs generally were placed in three different land use types, namely forestry areas (pine forest) 94 units, residential area 35 units, and mixed farming 10 units.

Infiltration ponds are constructed and employed to artificially recharge aquifers, impacting spring discharge and run-off. Artificial recharge of ground water is achieved by putting surface water in watershed, furrows, or other facilities where it infiltrates into the soil, and moves downward to recharge aquifers. Artificial recharge requires permeable surface soils. Run-off simulation was done through pouring 8 cubic meter water into each infiltration pond. The hydrological model, using SWAT (Soil Water Assessment Tools), was developed using historical (existing) data and field data for calibration of parameters. Spring flow, soil type, land use type, river network and topographical information was gathered for exact locations, while other data were gathered from within a radius of 50 km from the location. Soil related data collection sites were determined through soil maps and Hydrological Response Units, (HRU). Field data collection activities include observations of the physical properties of the soil, land cover, water table, and measurement of hydraulic conductivity. The model developed was calibrated and then retested to ensure that it effectively models the past and present spring discharge. The relationship between the observed data and data from the SWAT model has a coefficient of determination $R^2 = 0.756$;. These indicate that the SWAT represents field conditions accurately.

GW_Delay factor (ground water delay), ALFA_BF (base flow alpha factor), and CH_KI (Manning's "n" for tributaries), related to land cover type, affect the size of the discharge at Jubel spring. Travel time is 357.3 days, almost 1 year, indicating that holding capacity and ability to retention the water is long enough in Catchment

Jubel, thus increasing or decreasing rainfall and land cover changes will be impact to spring discharge on the next year. The average amount of surface run-off that could be captured by infiltration ponds was 98.9 m^3/well/year. As indicated through the SWAT analysis, construction of infiltration ponds can improve the flow of springs, 0.28 l/s. The increase in discharge will start in March and the highest increase will be felt between August and October where the supply of water is historically lowest; the additional water supply will be very significant and will increase service. The infiltration ponds reduce surface run-off that in turn to increase water discharge at the water springs. The decrease in surface run-off in 6.34%. Increased spring discharge results in more water being available to the population, and less seasonal fluctuation. Construction of 1 unit of infiltration pond in the catchment areas can increase the number of customers 3 people.

Keywords

SWAT, infiltration pond, IUWASH, Jubel, artificial recharge, aquifer

Impacts of Land Use Change on Southeast Amazonia Basin Streamflow

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Abstract

Due to the scenario of economic development that Brazil is going through, the demand for electricity has increased, forcing the Brazilian government to plan and construct new plants in order to supply the energy that the country needs. One of those plants is the Belo Monte hydroelectric power plant, situated in River Xingu, on Southeast Amazon Basin. The watershed where the plant is located is very famous around the world because of its wildlife diversity, thus it is necessary to plan ahead how the resources are going to be used and reduces the environmental damage the exploitation causes. For this purpose it is necessary to calibrate and validate a model, which helps to verify how interventions on soil uses, land cover and a hydroelectric in the main river of the basin is going to effect the entire Xingu watershed. MODIS remote sensing products were applied to land cover change detection in the Amazon. SWAT model is being used worldwide to simulate different scenarios around the world and it is going to be used to simulate the streamflow on River Xingu basin, therefor it will be possible to improve the management of the water resources. To calibrate and validate the SWAT model it will be used a database which has been previously prepared using observed data and measured data from two monitoring stations belonging to ANA – National Water Agency, to compare the results generated by the model and the streamflow measured on the river.

Keywords

Amazonia; Streamflow; Calibration and Validation

PRISM Climate Data Effect on Flow Calibration and Uncertainty of a SWAT Model Including Septic Systems

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Abstract

PRISM (Parameter-elevation Relationships on Independent Slopes Model) precipitation and temperature based in part on radar were used in a SWAT model and compared to a model that used CFSR (Climate Forecast System Reanalysis) data. The watershed was 44 square km in area and located in suburban Atlanta, Georgia, USA where septic systems are commonly used. The model was calibrated using stream gauge data for the period 1/1/2003 to 12/31/2006. The SWATCUP SUFI-2 program was used for auto-calibration with Nash Sutcliffe Efficiency (NSE) as the performance measure to emphasize the effect of peak flow during storms. Using the CFSR data, 10 parameters were found to be sensitive for stream flow and the daily NSE was 0.46 with a p-factor = 0.75 (fraction of observed values within the uncertainty band) and r-factor = 0.52 (ratio of uncertainty band and standard deviation of observed flow). With the PRISM data, the daily NSE increased to 0.64 with a p-factor = 0.78 and an r-factor = 0.50, indicating a better fit to the high flow data. Four out of 10 sensitive parameters were different using the PRISM data. Septic systems accounted for 2-5% of the stream flow, depending on the year.

Keywords

calibration, uncertainty, septic systems

Does the use of fine climate stations grid and sub-basins delineation improve the modelling of river discharge and sediments fluxes at hourly time-step? Application of the SWAT model to Mediterranean flash floods

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Abstract

Global change is expected to increase the frequency of intense rainfall events and consequent flash floods across the Mediterranean coastal basins in the next decades. To date, few models are able to simulate hydrological processes at basin-scale at a reasonable time scale to describe these flash events with accurate details. They are often complex physically-based distributed models and do not capture below-ground processes. The SWAT model assumes several simplifications but has recently been upgraded to sub-daily time-step calculations. However, its sub-daily module has only been tested in small catchments ($\sim$1 km^2). The objectives of this study were (1) to assess the ability of the SWAT model to simulate discharge and sediment fluxes at hourly time-step in the $\sim$1400 km^2 Têt Mediterranean river basin (southwestern France) and (2) to assess the possible gain of model's performance when using fine grids of climate stations and sub-basins representation. We modelled the Têt basin with two sub-basin delineations of 1500 and 25 ha drainage areas, and with three climate stations grids of hourly meteorological data (NCEP CFSR, 30 km; SAFRAN, 8 km; and Meso-NH, 500 m). We calibrated the 6 resulting Têt

models at hourly time-step with the upgraded version of the SWAT-CUP autocalibration tool, based on the hourly measured discharge of 7 gauging stations (2000-2014) and on the hourly measured suspended sediment concentration of 1 gauging station (2003-2014). We then compared the performances of the 6 models. This ongoing work will provide guidance for future hourly time-step modelling with the SWAT model.

Keywords

Sub-daily simulation, Meteorological grid, Sub-basin mesh, Flash floods, Mediterranean watershed.

Assessment of uncertainty in SWAT using variable spatial data resolution and sensitivity calibration in a meso-scale watershed in the Blue Nile Basin, Ethiopia

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Abstract

Watershed simulations are highly sensitive to resolution of input data and on how well spatial parameters describe the characteristics of a watershed. Publicly available data from different sources make modelling more accessible in data-scarce regions like Ethiopia. But, without careful understanding of the influence of resolution on modelling results there is limited significance to model outputs in the real world. This study uses the Soil and Water Assessment Tool (SWAT) to determine the impact of different input data resolutions on simulated discharge and sediment loss in a meso-scale catchment in the Ethiopian Highlands. The final goal is to determine a suitable set of input data for a later large-scale simulation in the Blue Nile Basin. The research watershed set up for the purpose of this study is a $46 km^2$ catchment, which is calibrated using combinations of DEM resolutions (5x5m, 30x30m), soil map resolutions (1:10,000, 1: 5,000,000), and land use resolutions (field-scale, 90x90m). Three scenarios with high, medium and low resolution are created, calibrated and validated first for discharge and in a second step for sediment loss. Scenarios are calibrated and validated in a sub-catchment ($1 km^2$) with long-lasting time-series using the Sequential Uncertainty Fitting program (SUFI-2) before being validated in the entire $46 km^2$ large catchment.

Keywords

Uncertainty assessment, calibration, SWAT, SUFI-2, Ethiopia, meso-scale, resolution, spatial data

How SWAT and hydrological modeling can help in dealing with water resources and land management in Italy and in the EU

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Abstract

Land managers and policy makers face the need of taking informed decisions when dealing with the implementation of National and EU-level legislation on the field of water resources (quantity and quality) and land use management. The decisions to be takes must be based on strong scientific basis and must take into account all the complex relationships existing in complex hantropized environments. The presentation aims at discussing an overview of how SWAT and hydrological modelling could help local and National Administrations in answering the challenges given by national and EU legislation, with specific reference to different steps of the Water Framework Directive, Nitrate Directive, Common Agricultural Policy, landscape planning, flood prevention, erosion control with reference to pratical cases.

Assessment of the water resources of the Sardinian Island using SWAT

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Abstract

Hydrological modeling requires optimal use of available information, which is a cause of uncertainty in model structure and parameters. The level of model complexity must be supported by available data, and be balanced with the level of usability suitable for the desired application. In this work we address the issues and challenges in setting up an observation and assessment system at the catchment scale based on SWAT for the management of water resources in Sardinia. SWAT is employed to model the island's hydrological cycle, which comprises 108 catchments, each characterized by a rich variety of soil, land cover and geo-morphological regions.

We applied a semi-automated inverse modelling routine (SUFI-2) for calibration and uncertainty analysis. The model has been calibrated and validated using stream flow data obtained by 27 monitoring gages scattered across the island. In this situation, water balance components and stream flow predictions are challenging tasks due to the lack of control data for most watersheds. The model performance measured with the Nash-Sutcliffe Index scored an average of 0.75 in calibration which was confirmed in validation. No matter how powerful the model, we must accept the fact of the implicit complexity and limit of the calibration process and we must explicitly recognize the role of model error.

Annual and monthly simulations with the calibrated model for Sardinia show good results with respect to the quantification of water balance components but also indicate the importance of evaluating the uncertainty of parameters and of the conceptual model.

Keywords

SWAT, Water Budget, hydrology, Sardinia, Swat Cup, Calibration, validation

Using SWAT in two mega-scale watershed projects: Challenges and Results

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Abstract

Higher standards of living, population growth, demographic changes, land and water use policies, higher demand for food security, and other external forces are increasing pressure on local, national and regional water supplies needed for irrigation, energy production, industrial uses, domestic purposes, and the environment. In many parts of Europe water resources quantity and quality has come under server pressures and water levels have decreased, resulting in negative environmental impacts. Rapid, and often, unpredictable changes with regard to freshwater supplies create uncertainties for water managers. At the same time, climate change adds a new level of uncertainty with regard to freshwater supplies and to the main water use sectors such as agriculture and energy, which will in turn exacerbate uncertainties regarding future demands for water. As meeting future water demands becomes more uncertain, and water scarcity is continuously increasing, societies become more vulnerable to a wide range of risks associated with inadequate water supply in quantity and/or quality. In recent years we used SWAT in two mega-scale European projects to determine the water resources and water quality of the Black Sea region (2 mKm^2) and the entire Europe (10 mKm^2). The SWAT models, which included agricultural management were calibrated based on river discharge, surface water nitrate concentration, and crop yield. Challenges with model building and calibration are discussed.

Trans-boundary Water Conflicts: Tigris River basin case study

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Abstract

Tigris-Euphrates basin is one of the oldest civilizations in the world dating back to 5000 BC. The basin is shared between four countries (Turkey, Syria, Iran and Iraq). Until now the water allocation and management were done on limited basis between the countries and within the country due to the way the water resource policy and governance in general were implemented. Since 1990 due to high tension in Iraq, more recent tension in Syria and embargo to Iran has all lead to total imbalance of water allocation and management. In addition, starting from mid-1980 there are several dams were constructed and proposed in various tributaries of the Tigris basin within Iraq, Turkey and one dam in Iran. All these existing and new structures along with general decline in rainfall pattern in the last 30 years have created greater uncertainties to have a viable open water management plan. To have an open debate about the availability of water resources over three decades and it sources, allocation for various sectors and environmental flow to maintain the world largest inland marsh namely Al-Hawizeh, a SWAT model has been created. This paper will present various ways to mitigate the tension due to water across the basin will be discussed including, overviews of the hydrological analysis (flood/drought frequency, intensity and probability of exceedance) of flow in the Tigris and its tributaries (including Karkheh river flowing from Iran) feeding the marsh using calibrated SWAT model. Also the impacts of current and future dams on flow contributions are explored.

Effect of Physical Catchment Characteristics on River Flow: The Case of Ribb and Gumara Rivers in Upper Blue Nile, Ethiopia

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Abstract

Stream water quantity and quality are dependent on the physical characteristics of a catchment. The effect of physical catchment characteristics (PCCs) on river flow is not adequately investigated in the upper Blue Nile River Basin. We selected two adjacent watersheds, Ribb and Gumera, of comparable area but significantly different long-term mean annual yield. Twenty PCCs of the watersheds that possibly affect catchment yield are extracted and their relative percentage difference is examined. Then using a Soil and Water Assessment Tool (SWAT) hydrological model the effects of PCCs is grasped by simulating Ribb using Gumara areal average model parameters sets at hydrologic response unit and sub-basins level. The percentage difference in physical catchment characteristics indicated no appreciable difference in climate and physiographic characteristics, a moderate difference is in land cover/land use type and a major variation in the soil types. The hydrological model performed well in capturing the observed flow for the calibration period from 1995 to 2004 with a Nash-Sutcliffe Efficiency of 0.68 and 0.71 for Ribb and Gumara, respectively and with a Percentage Bias of less than 10%. The percentage difference of fitted model parameters has captured the major variation of soil in Gumara and Ribb watershed by a significant difference on ground water, saturated hydraulic conductivity and soil depth. The modeling result indicated that a minor increase of flow of Ribb River is observed after Ribb calibrated parameters rerun in combination with Gumara areal slope, soil and channel parameters. Ribb river flow has significantly increased for Gumara areal runoff, evaporation parameters and groundwater parameters. Ribb model rerun by Gumara rainfall assuming Ribb watershed receives the same amount of Gumara areal rainfall indicated that, the annual average river flow of Ribb will increase by 4.3 percent.

Keywords

SWAT, hydrologic response unit, HRU, Lake Tana

Modeling Dynamic Soil Properties in APEX for U.S. Soil Survey

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Abstract

Historically, soil survey products described inherent soil properties for an entire soil profile under common land use. The National Cooperative Soil Survey (NCSS) recognizes the need to provide enhanced information about soil change in response to land use, management or climate changes. Projects are ongoing to collect and aggregate dynamic soil properties (DSPs). These projects focus on surface layers that respond most rapidly to changes in management or land use. While changes in DSPs are best measured over time through long-term studies and monitoring, changes in DSPs can be estimated using soil survey methods by careful space-for-time substitution comparing land use or management conditions (i.e. vegetation, tillage, chemical, and organic inputs) on the same soil. A combination of modeling and data collection will allow soil survey to quickly populate a comprehensive DSPs database and inform conservation tools. APEX, a comprehensive model (weather, hydrology, soil erosion-sedimentation, plant growth, nutrient cycling, soil temperature, soil moisture, tillage, and plant environment control) was evaluated for use in populating DSPs for soil survey. Soil survey DSPs can be used in conservation tools to assist land managers in their evaluations of likely management impacts on soil properties. Of particular interest is the resistance and resilience of soils to change when disturbed by cultivation.

Keywords

APEX, soil survey, soil change, dynamic soil properties

APEX and the CEAP Assessment of Conservation Benefits on Grazing Lands

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Abstract

The goal of USDA-NRCS Conservation Effects Assessment Program (CEAP) is to improve efficacy of conservation practices and programs by quantifying conservation effects and providing the science and education base needed to enrich conservation planning, implementation, management decisions, and policy. APEX and SWAT are central to the analysis of conservation effects by CEAP. The latest CEAP assessment is of rangeland, which in the western US is predominately semi-arid. This presents a new set of challenges for APEX which was originally developed for row crops. We report here on the new APEX process-based simulations on grazing lands. The latest additions to APEX are designed to quantify effects of different conservation scenarios and practices on natural resources at variable scales; aid in the selection of best practices to treat resource concerns; and aid in the geographic placement of best practices to optimize conservation effects. In order to model rangelands, their plants and grazing animals, new features in APEX include, plant basal area, forage digestibility, and selective grazing developed from the PHYGROW grazing land assessment model. The incorporation of PHYGROW features enriches APEX's ability to model livestock herds, specifically selective grazing by lactating cows, dry cows, calves, and yearling cattle. APEX models multiple herds (sheep and goats as well as cattle) grazing the same area at the same time. Intake and excretion vary with diet quality, and grazing/browsing of trees or shrubs are also modelled. Forages are classified as Preferred, Desirable, Undesirable, or Not-consumed. Preferred forages are consumed in greater proportions than their proportion of standing mass and undesirable forages are consumed in smaller proportions than their proportion of standing mass. The same forage species can be in a different preference class for different grazer species. Critical outputs are animal performance based on grazing preferences and proportion of livestock intake from each preference class as a function of time. These new features will be released for use by users in the near future.

Keywords

Animal performance, forage, livestock, plant preference, plant quality, selective grazing

Changes in the fate of pesticides used in cotton production systems under potential climate change

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Abstract

The United States is the leading cotton exporter, growing cotton in 17 southern states. Plant competition and insect pests are major constraints on efficient cotton production. Pest management imposes significant costs and environmental problems in cotton production as it is one of the most pesticide-intensive commodity crops. Pesticides used on cotton have the potential to contaminate ground and surface water and kill beneficial insects and soil micro-organisms if not managed properly. It is necessary to quantify the environmental impact of cotton production systems on water and soil quality under climate change in the long run, and to identify conservation practices that may effectively reduce negative impacts. Cotton production both dryland and irrigated was simulated in four states. Three time periods were simulated, 2001-10, 2021-30 and 2081-90, using weather data developed for the IPCC SRES-A2 CO2 scenario by the Geophysical Fluid Dynamics Laboratory CM2 climate model. SRES-A2 was thought to be a fairly pessimistic scenario, but now seems to be a highly plausible outcome over the next century. With increasing temperatures and CO2, cotton productivity is expected to change both up and down, depending on soils and the details of projected changes in weather. Pesticide (herbicides and insecticides) fate is also likely to change with different soils and weather patterns. We report on the probable changes in environmental contamination by pesticides used in cotton production over the three decade periods under the SRES-A2 scenario. At most sites and soils both surface water and sediment contamination increased between 2001 and 2090 with the greatest increase occurring between 2001 and 2030. The severity of the increase varied between active ingredients.

Stream Flow Modelling of Flat Watershed under Conditions of Limited Data in Semi-arid Region: Case Study of Euphrates River in Kufa Basin, Iraq

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Abstract

Among many challenges, Iraq also faces a serious problem of water resources shortage, as the country relies heavily on surface water from two main international rivers whose limited flows are further complicated by the fact that no international agreements have been reached to share the water wisely. Consequently, Iraq's water resources vary from one year to another. It has been also projected that the flow of Tigris and Euphrates rivers will continue to decline with time and they will be totally dry in 2040. It is of great value to have a clear understanding of water availability in the region to facilitate integrated water resources management (IWRM). Hydrological model-based stream flow simulation has been widely applied in many decisions making process in particular the management of water resource and land in the watershed. Reliable and accurate prediction of river discharge apart from its complexity is a vital part for resourceful water resources planning and management especially, for an arid and semi-arid regions like Iraq. This study aims to present a preliminary estimation of the performance of modelling of complex watershed in estimating water flow on the Euphrates River in Kufa basin, Iraq. The modelling of this catchment area is considered to be complex due to the local topography (very flat) and the local semi-arid climate (around 160 mm annual precipitations). The lack of data also makes modelling very challenge especially when the usually low flow is frequently interfered by human activities, such as water withdrawal. The model of stream flow has been constructed by utilising Soil and Water Assessment Tool (SWAT), package (ArcSWAT). A special procedure has been applied to improve the catchment delineation generated by the SWAT. The SWAT model is then calibrated and validated using flow data collected locally over the period of 2005-2014. The climate data are collected locally from Najaf climate station, while the soil and land use data are taken from Food Agricultural Organisation (FAO) and United States Geological survey (USGS) websites respectively. The preliminary results show that the model was able to capture the flow pattern although more vigorous calibration is needed to further improve the model performance. It is envisaged that the SWAT model when fully examined and approved, will be used to couple with a MODFLOW based ground water modelling component, package (mflab) to support a systematic study of water resources management for the region.

Keywords

Hydrological modelling, SWAT, ArcSWAT, Stream flow modelling, Iraq, Semi-arid region, Euphrates River, Kufa.

Quantification of the partitioning of precipitation over the Almadinah watershed, Saudi Arabia using SWAT model

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Abstract

One of the largest watersheds in the Kingdome of Saudi Arabia is Almadinah watershed with an area: ~108,000 km². The partitioning of precipitation into runoff, recharge, and evaporation over the Almadinah watershed was estimated using the Soil Water Assessment Tool (SWAT). The SWAT model inputs include: (1) rainfall from the Tropical Rainfall Measuring Mission (TRMM), (2) soil data from the geologic maps generated by Saudi Geological Survey, (3) land use from the U.S. Geological Survey (USGS) 1-km global Land Use and Land Cover database, (4) topography from the Shuttle Radar Topography Mission (SRTM; 90 m spatial resolution) data, and (5) climatic inputs (solar radiation, wind speed, air temperature, and relative humidity) from the Climate Forecast System Reanalysis (CFSR) database. The constructed SWAT model was calibrated against the discharge data extracted from the archival runoff datasets. Model outputs over the Almadinah watershed for period from 1980 to 2010 indicated that the average annual rainfall, stream flow, potential recharge, and initial losses are 58 mm, 19.1 mm (33% of the rainfall), 7.2 mm (12.5% of the rainfall), and 31.3 mm (54% of the rainfall), respectively.

Keywords

Almadinah watershed, Saudi Arabia, SWAT model

A SWAT model for Denmark

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Abstract

The IMAGE alliance is an interdisciplinary consortium designed to establish a body of knowledge, which can provide a common ecosystem-based decision platform. Based on a series of integrated models, IMAGE aims to develop decision support tools and scenarios that describe the interplay between science and management of agriculture, fisheries, aquatic environments and welfare economics, with principal focus on the Danish marine waters within the Baltic Sea. The SWAT model has been chosen as the tool to model riverine water and nutrient loads from the drainage basin (area of Denmark 43,000 km^2) to the sea. High intensive agriculture plays an important role in the drainage basin with 62% of the Danish land area being cultivated. Parameterization of the SWAT model is performed on a very detailed data set, containing e.g. information at the field and farm level of all Danish farms. Concurrently, modifications to SWAT, with particular focus on phosphorus cycling, are being performed and validated based on these data sets. For computational reasons the drainage basin is divided into seven regions, each with individual SWAT models. Our modeling concept and results will be demonstrated.

Keywords

Catchment modelling; SWAT model; Denmark

Application of the SWAT model for estimating Discharge and Water Quality from rice paddy site in the Yeongsan watershed, Korea

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Abstract

The accurate quantification of pollutant loads and discharge from watersheds and the prediction of water quality in receiving waters are important for the effective application. Mathematical modeling can be used to estimate flow and pollutant. The Soil Water Assessment Tool (SWAT) model have functions that can simulate flow considering various hydrological condition; transport of various nonpoint sources; and management for landuse and flood control. However, application of SWAT is limited in paddy fields, which have various behaviors. In this study, we conducted monitoring and SWAT application in a rice paddy field. We manually modified Digital Elevation Model (DEM) and used Geoprocessing function of Arcview to map out the reach of paddy. Field monitoring was conducted during a period of four crop-years (from May 1, 2005, to September 30. 2010) in a rice cultivation paddy. We also monitored irrigation flow and farming scenario for SWAT application. The observed annual runoff data from 2005 to 2010 were 506.71–794.21 mm while the simulated annual runoff data were 458.21–776.12 mm. As well, we used 0.18 as parameter of soil available water content (SOL-AWC) for simulating TN loadings in paddy, because the soil of paddy was almost saturated. The TN loadings of observation were 1.14-2.85 kg/ha and simulation were 1.65-3.47 kg/ha. This study present that SWAT application of paddy is useful for agricultural management and mitigating runoff and TN in paddy farming regions.

Keywords

Rice paddy, TN, TP

Hydrologic evaluation of the curve number and Green and Ampt methods in a tile-drained catchment using SWAT

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Abstract

Artificial drainage can contribute significantly to nutrient pollution in surface waters of tile-drained catchments. A realistic estimation of nutrient sources such as surface runoff, tile flow, and groundwater flow is essential in order to be able to predict nutrient loads realistically. The Soil and Water Assessment Tool (SWAT) provides two options for separating surface from subsurface flows, the empirical curve number and the physically based Green and Ampt method. In this study, we evaluated both rainfall-runoff models for a small tile-drained agricultural catchment in northeastern Germany using observed data from 2004-2013 and applying the recently introduced Hooghoudt and Kirkham tile drain equations. Model performance statistics indicated that the curve number method performed better than the Green and Ampt method. Nash-Suttcliffe efficiencies (NSE) for discharge on a monthly basis were 0.64 during calibration (0.73 during validation) for the curve number and 0.49 (0.63) for the Green and Ampt method. Tile flow was predicted with NSE values of 0.49 during calibration (0.64 during validation) for the curve number and 0.36 (0.61) for the Green and Ampt method, again on a monthly basis. The proportions of surface runoff, tile flow, and groundwater flow differed strongly between the two rainfall-runoff models, which might have implications for the modeling of sediment, nutrient, and pesticide transport and loads. Different values for tile drain depth and spacing affected discharge totals using the curve number method, while discharge was independent of the tile drain parameters using the Green and Ampt method. Greater tile drain depth and narrower spacing resulted in increased tile flow for both rainfall-runoff models. It can be concluded that the higher predictive power of the curve number method for daily and monthly evaluations makes it the better rainfall-runoff model for other SWAT application projects. Overall, our study revealed that the physically based tile drainage routines which make use of the Hooghoudt and Kirkham tile equations are a promising instrument for modeling tile flow with SWAT.

Keywords

Soil and Water Assessment Tool, rainfall-runoff models, tile flow, artificial drainage, catchment modeling

Modelling river discharge at sub-daily time-step: comparison of the performances of the conceptual SWAT model and the process-oriented MARINE model

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Abstract

Due to global change, the frequency of intense rainfall events and consequent flash floods are expected to increase in the next decades across the Mediterranean coastal basins. To date, few distributed models are able to simulate hydrological processes at basin-scale at a reasonable time scale to describe these flash events with accurate details. The MARINE model is one of them: it is a process-oriented fully distributed model operating dynamically at the rainfall event time-scale. Both infiltration and saturation excess are represented along with subsurface, overland and channel flows. It does not describe ground-water processes since the model's purpose is to simulate individual flood events during which ground-water processes are considered negligible. The SWAT model is a conceptual semi-distributed model assuming several simplifications in equations that dynamically simulates above- and below-ground processes. It has been recently upgraded to sub-daily time-step calculations. Considering the 1400 km² Têt Mediterranean river basin (southwestern France) as a case-study, the objective of this study was to assess and compare the performances of these two models when simulating the discharge at sub-daily time-step. We first calibrated the two models based on the same input dataset (topography, land-use, soil classes, and meteorological stations' grid). We then compared the performances of the two models on a number of selected flood events. This ongoing work will contribute to assess the ability of the SWAT model to simulate discharge at sub-daily time-step.

Keywords

Sub-daily simulation, Model comparison, Flash floods, Mediterranean watershed

Modelling river discharge and sediments fluxes at sub-daily time-step: Insight into the CRUE-SIM project devoted to Mediterranean coastal flash floods

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Abstract

The CRUE-SIM project (2014-2017) is an interdisciplinary project that brings together atmosphere physicists, hydrologists and oceanographers to study and model flash floods across the Mediterranean region : it integrates water and sediment transport as a consequence of intense rainfall, from the catchment to the sea. The objectives of the project are (1) the coupling between atmosphere, ocean and sea with continental hydrological and hydrodynamic models and (2) the integration of the feedbacks and the forcing continuity from one compartment to the other along the brief but intense events that will be studied. Considering the 1400 km² Têt Mediterranean river basin (southwestern France) as a case-study, two hydrological models will be used at different time and spatial scales: the low resolution SWAT model outputs will be used as the inputs of the high resolution MARINE model, both using rainfall forcing from the Meso-NH atmospheric model. The feedback of the storm surge on the downstream part of the basin will be considered thanks to the SYMPHONIE ocean model. We will quantify the fluxes, at a sub-daily time-step, of water and of suspended particulate matter transported during floods from the soil to the river and from the river to the sea. The CRUE-SIM project is one of the research lines of the SEDILION project funded by RTRA-STAE focused on the transport of dissolved and sorbed matter during flash floods.

Keywords

Sub-daily simulation, Model coupling, Flash floods, Mediterranean watershed

Hydrological modelling of the Bafing River (Senegal River basin): towards better management of the Manantali multipurpose dam

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Abstract

The Senegal River basin is about 300 000 km². It extends from rainy areas in north-eastern Guinea down to the sahelian part upstreams of Bakel town which is the entrance of the Senegal River valley. The Senegal River natural flow is highly irregular. Two dams have already been built for a better management of the floods. The first, the Manantali Dam, is a multipurpose dam, mainly for hydropower supply, low flow support, irrigation and flood protection in the valley. The Manantali Dam is built on the Bafing River, the main tributary of the Senegal River. The second is the Diama dam; it stops sea water intrusion and maintains a suitable level for farming activities in the valley. The association of these two dams also allows for water supply in towns located in the Senegal River valley. Most of the flow comes from the upper part of the basin. The main objective of this preliminary study is (1) to apply the physically based SWAT model to the Bafing river basin, upstream Manantali Dam to better assess the hydrology of this subbasin and (2) to suggest a better use of the water stored in the Manantali dam reservoir.

Simulating potassium load from a dairy farming watershed with the modified SWAT Model

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Abstract

Potassium (K) has been intensively used to optimize agricultural crop yield. K losses in the environment need to be accurately quantified for sustainable nutrient management. However, no hydrologic model has been yet developed to quantify daily K losses at watershed scale. This study attempted to implement K dynamics and K riverine losses at watershed scale in the Soil and Water Assessment Tool (SWAT) model and to apply this new module to the case of the Shibetsu River watershed (SRW), Japan. The SWAT model was modified (SWAT-K) by including the main K dynamic processes (solid-liquid distribution, plant uptake, and transportation with water movement and soil erosion) to simulate river soluble K load and K budget in the dairy farming watershed of the Shibetsu River. The comparison between SWAT-K simulation results and measurements showed that SWAT-K was able to satisfactorily predict the daily in-stream soluble K loads at SRW outlet station during the 2003-2004 period. The model performance yielded R^2 of 0.59, E_{NS} of 0.42 and PBIAS of 35% for calibration period, and R^2 of 0.57, E_{NS} of 0.39 and PBIAS of 24% for validation period. In addition, simulated plant uptake was close to observed value during 2003-2008 (PBIAS = 2.1%). Simulation results showed that the soil exchangeable K surplus was much more than plant uptake. The large amounts of soluble K leached to groundwater and exchangeable K stored in the soil indicated that agricultural K input might be excessive respect to the permissible limit in drinking water (12 mg L^{-1}) and reducing the amount of applied K is recommended. As a conclusion, the new module for K dynamic implemented in SWAT model gave very good results in this first application and it is now able to be applied and tested in other agricultural watersheds under different soil and climate conditions.

Keywords

Potassium; Crop uptake; Stream load; Potassium budget; Modified SWAT model

Hydrological modeling in a semi-arid area with SWAT, Case of Wadi Wahrane (Algeria)

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Abstract

Hydrological modelling in semi-arid area has always posed a major problem for modelers‹ despite considerable progress in practice of the rainfall runoff relationship, the majority of the studies in the arid are made by lumped models, although certain aspects of hydrology of arid and semi-arid zones are better suited to the simplified modeling, it is very plausible that biggest mistakes and uncertainties will continue to characterize the results of the rainfall-runoff relationship. The aim of our study is to adapt and to evaluate the SWATmodel to simulate the hydrological response in a context of semi-arid climate very contrasty. For this we apply the model in the watershed of Wadi Wahran (262.9 km^2) which located in the North of the Algeria characterized by a semi-arid climate with an aridity index AI = 0.27 and which receives about 400 mm rain per year, it is a sloping catchment with an integrated stream network.

The choice of calibration period it is not easy because the observed daily flows contain truncated values and a discontinuous Chronicle of records. We took the period of 1983-1993 for the calibration and the period 2005-2009 for validation. The model had split annual rainfall in ET (62%), ground water recharge (26%) and outflow (12%). The values obtained to estimate the quality of calibration and validation are respectively Nash 0.6 and 0.5; R^2 (coefficient of determination) 0.7 and 0.54, these results are satisfactory from the point of view of non-homogeneity of periods of calibration and validation, the calibration period is drier than the validation period, the lack of information on agricultural practices, the pumping illegal of groundwater, primarily in the Wadi beds and include a the resolution of the soil map. Recommendation for future research to minimize the differences between simulated and observed, it's minimize uncertainties in daily flow data and include a good information with personal investigation in the field, to better follow the various uses of water in the watershed.

Keywords

Hydrology modeling, semi arid, SWAT, Wadi Wahran, Algeria

Application of the MIKE 11 Ecolab Modeling System in Assesment of Spatial and Temporal Changes of Conductivity - A Case Study Drweca River Northen Poland

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Abstract

In the last decade the simulation models are considered as a powerful technique in the planning and development of integrated approaches for management of water resources. Thus, use of modeling tools and software became indispensable for various investigations of physiochemical pressure on the river's ecological quality. In this paper the integrated MIKE 11 system comprising of a hydrodynamic model and a water quality model, was applied to investigate the spatial and temporal variability of conductivity in the Drweca River, Northern Poland. The simulation and calibration of the model has been done using river channel characteristics and conductivity measurements in normal conditions. After the calibration, the model was used to simulate different accidental scenarios therefor provided results regarding the conductivity changes at small time steps. Ultimately, the proposed modeling system will enhance understanding the influence of conductivity in tracking the movement of water systems.

Keywords

modeling system, MIKE 11, spatial variability, conductivity, Drweca River

The SWAT model to assess hydrological processes in arid environment (SE Tunisia), in the frame of WADIS-MAR project

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Abstract

Arid regions of Maghreb (North Africa) suffer scarce water conditions and the erratic behaviour of rainfall events over brief intervals often produce short and intense floods events which converge into ephemeral *wadi* beds. The watershed of wadi Oum Zessar, in South-East Tunisia, is characterized by a rainfall rate of about 200 mm/year, overexploitation of groundwater resources and is highly exposed to climate change risk and desertification processes (Ghiglieri et al., 2014). This region represents one of the two study areas in the framework of WADIS-MAR demonstration project (www.wadismar.eu), funded by the European Commission under the Regional

Programme SWIM (www.swim-sm.eu). WADIS-MAR Project aims: (i) to improve the traditional water harvesting systems (i.e. *jessour* and *tabias*) by applying "soft" modern rehabilitation interventions; (ii) to increase groundwater availability through managed aquifer recharge (MAR) systems (i.e. gabions, recharge wells, recharge trenches). *Jessour* and *tabias* capture surface runoff coming from degraded and rocky rangelands for crop production (fruit trees, mainly olives, and cereals) in upstream subbasins.

The objective of this study was to assess the main hydrological processes and the sediment loads in this arid environment, by using the Soil and Water Assessment Tool (SWAT) model. Sediment load is an important parameter to be considered in the MAR systems because it may causes the clogging of the infiltrating surface, resulting in the reduction of water infiltration rates. The watershed delineation used the newly 2014 released SRTM 1 Arc-Second digital elevation model, available at www.earthexplorer.usgs.gov. A land cover classification obtained by visual interpretation of Landsat data was used for the modelling. Conversion to land use was supported by ancillary and detailed ground truth data.

The classic version of SWAT was adjusted to adapt the model to this dry Mediterranean environment (Ouessar et al., 2009). In SWAT, subbasin may be divided into Hydrologic Response Units (HRUs) which possess unique landuse/management/soil attribute. Normally, the runoff from all HRUs is added directly to the outlet of the subbasin. In this study runoff is routed between HRUs within the subbasin. The main adjustment consists of allowing the simulation of the runoff collection behind the water harvesting structures by bringing the surface runoff and lateral flow generated by different HRUs within the same subbasin. Moreover, existing gabions and recharge wells were considered in the model for a more accurate simulation of the hydrological processes. Possible coupling with MODFLOW will be considered. After calibration and validation, the model will be also used for evaluating the efficiency of the MAR systems which are being realized within the WADIS-MAR project.

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Keywords

SWAT, water harvesting systems, MAR systems, Tunisia, WADIS-MAR

Simulation of Soil Water Regime in Sofia Region Using SWAT and Newhall Models

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Abstract

The objective of this study is to characterize the soil moisture regime of Deluvial meadow soil in Sofia region. The soil moisture regime is classified according to Soil Taxonomy (Soil survey staff, 2010) using the model of Newhall (1972) for each year of the period 1952-2012. The SWAT model was run on a small watershed in Eastern part of Sofia field. Model simulations in selected sequence of years are compared with measurements of soil water content of Deluvial meadow soil in the experimental field Gorni Lozen, situated within the watershed. The results show good coincidence between measured and simulated soil moisture status. The year corresponding to the mean long-term annual precipitation is with Ustic type soil moisture regime. This type occurred with lower frequency than the other established types – Xeric and Udic in the studied periods. The frequency of the moisture regimes in normal years of the periods 1952-2012 and 1961-1990, are as follows: 29 and 32% - Udic, 34 and 32% - Ustic, 37 and 36% - Xeric, correspondingly. The simulation results show that soil moisture regime varies significantly throughout the years in the region of Sofia and it is not possible to point out the dominant type even for normal years. The obtained information is used for detecting soil moisture trends in the region. During the last period (1980-2012), the frequency of Xeric regimes in normal years increases up to 52% on account of Ustic type, which diminishes down to 17%.

Keywords

Soil moisture regime, climate variability, Newhall Model, SWAT model, Deluvial meadow soils, Sofia field.

Water retention assessment in traditional agricultural landscape (case study Liptovská Teplička, Slovakia)

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Abstract

At present, problems of storm rainfalls and the resulting floods and droughts as a consequence of climate change are becoming increasingly frequent in Slovakia. Over the last decades the typical landscape flood-protection measures were aimed to maximize the outflow of rain water from the territory. They were oriented to the landscape protection during the flood events and transformation of flood flow. However such concepts appeared to be not effective enough to mitigate the flood damage sufficiently. In our research we have focused on assessment of landscape water retention capacity as landscape property closely related to its diversity and biodiversity. We have studied these phenomena on landscape with character of traditional agricultural landscape (TAL) at Liptovská Teplička village. The pilot area Liptovská Teplička belongs to the best preserved TAL's in Slovakia. It is situated in the eastern part of the Low Tatra Mts. in the altitude from 846 m to 1,429 m. It belongs to the highest situated agricultural villages in Slovakia and has extreme relief-climatic conditions for agricultural production - steep slopes with rocky soils located in cold climatic region period with high susceptibility to flash flood and erosion events. The village during its historical development was characterized by the high level of parcels division resulting to high parcels density. Due to such spatial arrangement and high inclination, the landscape is characterized by high number of long and narrow parcels strips with field margins (balks) – forms of anthropogenic relief (mounds, heaps, terraces and their combinations). Despite of agricultural intensification in the last century there was a great number of such unique landscape elements preserved.

Our contribution is dealing with assessment of water retention function of field margins as important flood protection landscape elements. Geological bedrock, primary relief inclination, balk type and its height, slope, skeleton content, position of the balk towards the relief curve, land-use and management of balks and adjacent productive plots as well as climatic data in relation to root biomass have been studied as indicators of water retention function. The first results show the rocky-muddy mounds which are regularly mown and occasionally grazed with diagonal orientation towards the relief curve in the area of dolomites have the best retention capacity. The result can serve as a model of flood-protection measures in intensified large-block agricultural landscape situated predominantly in mountain areas. Further research is focused on modelling spatial distribution of soil moisture using in-situ sensors and assessment of retention capacity on watershed level.

Keywords

Water retention, traditional agricultural landscape

Preliminary results of the SWAT model application in an experimental rural catchment of the Brazilian savanna

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Abstract

The Upper Jardim Experimental River Basin covers an area of about 105 km², and is located in a rural zone of the Federal District, Brazil, in the core region of the Cerrado biome (Brazilian savanna). The first attempt to calibrate the SWAT model was performed on daily basis, using only two years of streamflow data measured on the downstream limit of the catchment. The first year of data, from August 2006 to July 2007, was used to calibrate the model, resulting in a Nash-Sutcliffe Efficiency (NSE) equal to 0.60. The other hydrological year, 2007-2008, was used for validating the model, but the results were not satisfactory (NSE = -0.84). The short size of the time-series and the huge difference in the hydrological behavior of the two studied years were identified as the main cause for this unsatisfactory result. On the second attempt, working on monthly basis, the same two years, 2006-2008, were used to calibrate the model (NSE = 0.71), and other two years, 2010-2012, were used to validate it. At this time, the results were considered satisfactory (NSE = 0.54). This catchment is massively monitored in terms of hydrological, soil and land-use data, and the group is working on the time-series enlargement to better support studies on hydrological, hydro-sedimentological and water quality modeling using SWAT.

Keywords

Short time-series, intensively monitored area, Cerrado Biome, Brazil

Appraisal of possible climate change impacts on the sediment yield in a rural catchment of the Brazilian savanna

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Abstract

Climate change may impact important hydro-sedimentological processes as erosion, sediment transport, and siltation. In many of the climate change scenarios there are indicative of modifications in the amount of precipitation and in the rainfall regime in different regions. This study aimed to evaluate potential impacts of changes in rainfall patterns on sediment yield in a rural catchment of the Brazilian savanna. The study was conducted at the Capão Comprido Experimental Basin ($\sim$16 km^2), in the Federal District, Brazil, using the SWAT model. Firstly, based on measured data, the SWAT model was successfully calibrated to simulate the sediment load in the catchment (Nash-Sutcliffe Efficiency equal to 0,5023). After that, four scenarios of changes in precipitation patterns were generated with basis on the Intergovernmental Panel on Climate Change predictions for the region (-10%, -5%, +5%, and +10%). These rates were applied on the daily rainfall time-series. The results showed that, on average, the relation between the precipitation changes and the sediment yield, in percentage terms, is directly proportional in a 1:2 ratio. This means that, when the amount of daily precipitation was increased in 5%, for example, the annual sediment yield in the catchment augmented in 10%. Even though it is a study using scenarios, it is interesting to note the sensitivity of the sediment yield due to changes in rainfall patterns.

Keywords

SWAT, rainfall patterns, sediment load

Hydrological modelling: River runoff modelling of large River basins in Estonia

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Abstract

In the last years there has been a progressive approach to the hydrological rainfall run-off modelling which can be used as primary method to evaluate the basin response to the most important modelling parameter- precipitation in both forms, liquid and snow. Hydrological rainfall-runoff models often require some degree of calibration and validation to achieve adequate basin representation of the study area. This is, however, only possible for gauged basins. There are many basins for which there are not monitoring discharge data available, it makes quite difficult the modelling but this disadvantage can be minimized extrapolating model parameters obtained through calibration of gauged basins to ungauged basins to simulate runoff. The aim of the present study was to implement, calibrate and validate a hydrological model to simulate the spring peak runoff, in gauged and ungauged basins of Pärnu River and Emajõgi River with a total area of 6910 km2 and 9960 km2 respectively (Loopmann A. 1979).

Both River basins are covered by forest and agricultural landscapes, most of the land is considered flat, under 5 percent of slope and the hydrologic soils are mainly well drained to moderately drained. The climate of this region follows the pattern of Northern regions of Europe with an annual average temperature of about 4,3 ℃ and 6,5 ℃, but the temperature usually falls down to negative centigrade during winter . Total annual average precipitation is 550– 750 mm with an evapotranspiration rate of 420 mm annually. The application of the model requires specific information about weather sources, daily max and min air temperature and precipitation recorded at the Estonian meteorological network, topography, soil characteristics and land use.

Model performance was evaluated using the Nash-Sutcliffe coefficient and Regression Coefficient was also used. During the calibration and validation periods the model is able to represent satisfactorily silhouette, volume, and peak of observed flow hydrographs and perform better some stations than others, it is shown by the variations in the results of Nash and R2 coefficients. All the model evaluation results during the different periods are over the values to be considered acceptable NASH > 0, 65 or good NASH >0, 75 and (R2) > 0, 5. (Moriasi D. N. et al 2007)

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Modelling Pesticide Contamination Under Baseline Conditions in Two Small Agricultural Catchments

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Abstract

Pollution from agriculture including the use of pesticides is one of the primary causes of degradation of freshwater bodies in the UK. Mitigation measures are known to reduce the quantity and concentration of agricultural pollutants at local scales, but their effect on chemical and ecological quality of water at catchment-scale is poorly characterised. The Water Friendly Farming (WFF) project is a Before-After-Control-Impact experiment in three 10 km^2 headwater catchments with extensive drainflow; a two year pre-works baseline has been established against which effectiveness of the mitigation measures can be evaluated. The SWAT model was used to simulate stream flow and pesticide losses to surface water under baseline conditions in the Stonton and Eye Brook catchments located in Leicestershire, UK. After simulation, sensitivity analysis and sequential uncertainty fitting (SUFI-2) were used for hydrological calibration. The Nash and Sutcliffe model efficiency coefficients (NSE) for daily stream flow calibration were 0.74 and 0.70 and r^2 were 0.74 and 0.71 for the Stonton and Eye Brooks, respectively, indicating a good model performance. The results for the model validation were within an acceptable performance. SWAT was able to predict the temporal pattern for peaks in pesticide concentrations. Simulated concentrations gave an excellent match to measured behaviour for the molluscicide metaldehyde, whereas peak concentrations were somewhat under-estimated by the model for two herbicides, carbetamide and propyzamide. The model is now being used to remove inter-year variability due to the weather in assessing the efficacy of a programme of mitigation measures.

Keywords

SWAT, pesticides, BACI experiment, subsurface drains, mitigation measures.

Hydrological modelling in highly anthropized basins: example from the Garonne basin using the SWAT model

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Abstract

REGARD (Modelling of Water Ressources in the Garonne Watershed: interaction between natural and anthropic processes and income from remote sensing) is a French Interlaboratory research program, aiming to explore how satellite data and information on human activity, combined with hydrological modelling, can provide a high spatial and temporal resolution of the water resource in the Garonne watershed in France (over the 2003-2013 period). Part of this program, handled by ECOLAB (LABoratoire ECOlogie fonctionelle et environnement) is realised using the SWAT model. Main tasks of the ECOLAB team within the project consist of implementing new processes in SWAT to improve the integrated approach of water ressources management in the watershed, quantifying the different water storage (Snow, soil, alluvial aquifer, dams and hillside reservoirs). Comparison of SWAT outputs with satellites data and/or with other hydrological simulations in the project (SURFEX/MODCOU from CNRM-GAME, MARTHE from BRGM, HEC-RAS from IMFT) are realised before and after improvements. Comparing snow cover from SWAT in the Pyrenees Mountains with the MODIS satellite data has already given succesful results and a monthly calibration of the model produce also a promising simulation. The team is now aiming towards the

following developments: integrating accurate dam's water outputs, implementing and testing a better representation of the ground-water and river exchanges in alluvial plains with a new spatial approach in the model (the Landscape Units (LU) SWAT version) and implementing new processes for hillside catchment reservoirs in conjunction with the implementation of better irrigation rules from outputs of MAELIA platform (http://maelia-platform.inra.fr/).

Keywords

REGARD project, anthropic processes, natural processes remote sensing, SWAT, Garonne River

Effects of GIS data quality on SWAT model stream flow and sediment simulations in a lowland watershed (NW Poland)

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Abstract

GIS-based water quality modelling results, such as the Soil and Water Assessment Tool predictions, are dependent on the quality of input data. Several studies have analyzed the sensitivity of SWAT to spatial parameterization including the impact of input data resolution and watershed sub-division. Still relatively little information is available on the effects of very high-resolution DEMs on model outputs. The aim of this study was to assess the influence of the DEM resolution and the soil database parameters on the water runoff and sediment yield outputs. The study included the evaluation of different soil maps available for the territory of Poland.

The study was carried out in the Parsęta river basin which is situated in the north-western Poland. The watershed is located in temperate climatic zone and represents a landscape typical for lowlands influenced by glacial and periglacial processes of the Pleistocene. Four different sources of DEM data were tested: DEM from LIDAR data, DEM created by interpolation of contour lines derived from the topographic maps on a scale of 1:10 000, DEM obtained from the Digital Terrain Elevation Data Level 2 (DTED2), DEM obtained from the CGIAR-CSI (SRTM v 4). Three sources of soil information were used: Digital forest map, Soil-agricultural maps, Harmonized World Soil Database (HWSD v 1.2). The collected data were analyzed in 12 various combinations.

The evaluation was performed using historical streamflow and sediment concentration data from the watershed outlet on annual, monthly and daily basis. The model performance was evaluated based on R^2, Nash & Sutcliffe model efficiency (NSE) and Percent Bias (PBIAS). The obtained results varied depending on the applied input data and adopted time step of the output data. The study indicates the possibilities and limitations of selected GIS data in the achievement of a required accuracy of the model prediction.

Keywords

SWAT, DEM resolution, soil database, lowland watershed

Impacts of water resources management on food security in China

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Abstract

Water is the key to food security. China is the second largest country in the world, and the natural resources and ground water are very rich in this country. However, with the remarkable growth of economy and population, development of industries, raising standard of living and expansion of irrigated agriculture, China has presented great challenges to manage water resources management. Besides, global climate change is posing great threats to food security and bringing additional uncertainty in water supply in China. Therefore, there is a high need to ensure effective water resource management to enhance food security, to qualify water and food patterns to address China's future food/water needs, and the spatial and temporal analysis of water resources and food production is highly needed. The aim of this research is to develop tools to evaluate the impacts of water resources management on food security in China, try to address the problems of water resources management in future water resources, the crop water use and the climate uncertainty impacts on water and food security in China. Simulating the potential parameters using crop water use model- here we use Soil and Water Assessment Tool (SWAT) model and linked Geographic Information System (GIS) of land properties.

Keywords

Water resources management, food security

Evaluating floods in the Kabul River basin of Pakistan with the SWAT model

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Abstract

Pakistan has suffered a devastating flood in 2010. In river Kabul large-scale riverine and flash floods occur every year and cause damage. The river Kabul basin of Pakistan is vulnerable to climate change. More and more severe floods are expected in the area. Flooding increases the concentration of the bacterium *E. coli* in the surface water. Our final aim is to better understand the impact of flooding on public health in the Kabul River basin. We plan to use SWAT to model the concentration of *E. coli* in the surface water to enable fate and transport studies and scenario analysis. As a first step, we modelled the Kabul River discharge. A detailed Digital Elevation Model (DEM), a land cover, and a soil map of the basin and meteorological data (1994-2014) are used to estimate the discharge. The model is calibrated and validated with stream flow data at two monitoring gages within the downstream basin of river Kabul. These data cover several floods. This is the first time that the SWAT model is used in the Kabul River basin. We will discuss the usefulness of SWAT in flood modelling for this region.

Keywords

SWAT, hydrology, Kabul River, flooding

Potential impacts of climate change on hydropower generation in the Tagus River Basin using an ensemble of climate scenarios

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Abstract

This study investigates potential effects of climate change on inflow and hydropower generation on selected large reservoirs in the Tagus River Basin (Spain and Portugal). Their ability to deliver electric power and secure water supply under changed climate conditions, assuming present water management strategies, is assessed. Five selected future climate projections under two emissions scenario from the Inter-Sectoral Impact Model Intercomparison Project (ISI-MIP, www.isi-mip.org) are used for the region. The climate scenarios were bias-corrected to the WATCH climate data in advance.

The Tagus River Basin is an important strategic water and energy source for Portugal and Spain. With an extensive network of 40 reservoirs with more than 15 hm3 capacity and numerous abstraction channels it is ensuring water supply for domestic and industrial usage, irrigation and hydropower production. Growing electricity and water demands, over-regulation and construction of new dams, large inter-basin water transfers aggravated by strong natural variability of climate and aridity have already imposed significant pressures on the river basin. A substantial reduction of discharge, periodically dropping to zero in some parts of the basin, is observed already now, and the projected climatic change is expected to influence water budget of the catchment further. As the water inflow is a fundamental defining factor for reservoir operation and hydropower production, the latter is highly sensitive to shifts in water balance, and hence to changes in climate.

The river basin scale, process-based eco-hydrological model SWIM (developed basing on SWAT-1993 and MATSALU), was set up, calibrated and validated up to the Almourol gauge close to the mouth of the Tagus, with implementation of the reservoir module. This module is able to represent three reservoir operation management options, simulates water abstraction and hydropower generation. The fifteen largest reservoirs in the Tagus River Basin were included in the model, calibrated and validated against observed inflow, stored water and outflow water volumes.

Keywords

SWIM, Tagus River basin, hydrology, water management, climate change

Assessing the effectiveness of Best Management Practices with the SWAT-GENLU modeling framework

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Abstract

Diffuse pollution from agriculture has become a major concern for **water managers**. To improve the water quality, agricultural mitigation measures **are widely used but not easy to evaluate on large territories.** We proposed an **integrated assessment method for public decision makers including the modeling of scenarios at the watershed scale**. We chose the SWAT model for its capacity to represent urban and agricultural practices. Implementing these practices at the HRU level through the standard interface can be tedious: thus 6 year crop rotation require circa 60 to be duplicated for all the agricultural HRUs and all scenarios.

We developed a program in order to facilitate the modeling of these mitigation measures: **GENLU1 (2007) for environmental modeling** and **GENLU2 (2012) for integrated assessment modeling**. Both versions enable building the SWAT management operation schedule and **targeting BMPs wholly or in part of the area**. It allows to implementing changes in molecules or crop management sequences or widths of filter strips. It manages a **temporal variability in dates of application**.

GENLU1 generates the landcover raster by spatializing data from the French Agricultural Census at the commune scale and spatial non-agricultural landuse. The associated management operation schedules are built from field studies and regional knowledge. **GENLU2** is dedicated to **integrated assessment modeling in which** agricultural practices are finely described at the group-of-plots scale using typologies (crop rotations * types of soil).

This ability to build up read-in SWAT alternative scenarios makes GENLU an appropriate tool for implementing the SWAT model with complex landuse and agricultural systems.

Keywords

SWAT. GENLU, BMPs, NPS, integrated assessment modeling, agricultural practices, NPS, water quality, mitigation measures, scenarios, cropping systems,

Identification of Environmentally Sensitive Areas and subsidies to a Management Plan for Watershed through techniques of modeling and GIS

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Abstract

The indiscriminate removal of original vegetation, especially for agricultural and livestock occupations, has generated serious environmental degradation. An example is the siltation of rivers and the deterioration of water sources that supply cities and rural areas and lend themselves to various projects. The Pinhal stream, source for the city of Limeira, (State of São Paulo, Brazil) falls within this context, as it suffers from degradation in the region as a whole. This work is the first to identify, through GIS techniques, three "Environmentally Sensitive Areas" (ESA's) that have suffered a degradation process in the Pinhal watershed. By using the Soil and Water Assessment Tool model (SWAT), the authors carried out simulations with both the current and alternative land use scenarios, considering the ESA's identified in the study that are protected by forest cover. The simulated scenarios were compared with the conditions of the current scenario in terms of the production of sediment and water production. There was a significant reduction in the production of sediments between scenarios, while the availability of water in the basin was also reduced.

Keywords

Mathematical models, pollution from diffuse sources, GIS

Hydrological Modeling River Tributaries San Francisco, the Brazilian Semiarid

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Abstract

The San Francisco is the largest river in length, which rises and flows in Brazil and is extensively used for the purpose of power generation, irrigation, human consumption and navigation. Due to a series of large dams, built for the purposes of electricity generation, the last stretch of this river is fully artificialized. In this context, this paper aims at studying the production of water and sediments from two tributaries, whose mouths on the São Francisco River are located in the same place, the Jacaré River and the Capiá River in the states of Sergipe and Alagoas in the semiarid region. The basic input data to run the hydrological model SWAT, such as soil type and its properties, use and land cover, slope, climate elements, have been properly compiled and registered in the program, as well as flow data for calibration and validation. The results showed that the water production from Jacaré River is between 141.47 a 148.69mm.ha.ano^{-1}, while the Capiá River is between 104.42 a 341.05 mm.ha^{-1}.ano^{-1}, both being dependent on rainfall, which concentrates on three months of the year. Sediments released by these tributaries, on the order of an average of 2.32t.ha^{-1}.year^{-1} are causing clogging problems in the main bed of the river, which is artificialized and subjected to a constant hydrological regime, the past two years.

Keywords

São Francisco River, Model hydrological, sediment

Effects of Variability Scenarios of Land Use on the Dynamics of Flow and Sediment in Jacaré River, Brazil

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Abstract

Mathematical models of prediction of water and sediment production provide a great help in planning and management of water resources due to the possibility of estimating impacts caused by the change in land use and occupation. Thus, this study aimed at analyzing the production of water and sediment in Jacaré water shed, a tributary of the São Francisco River, Sergipe - Brazil, for four scenarios of land use and occupation (current use, dry forest, agricultural and pasture). The application of the model was evaluated by comparing the simulated results, production of water and sediments for a period between the years 2011-2014. The results of the hydrological simulation for different scenarios show that the perspective of agricultural activities had the highest average annual production of water between the use and management of soils analyzed, with 4.65% more compared to current use, 3.36% higher than the dry forest (caatinga) scenario and 30.36% higher than the pasture. As for the sediment production, results showed that agricultural cultivation was also the largest producer, with an annual average of 3.32ton.ha^{-1}, representing much higher values than the other scenarios studied.

Keywords

Hydrological models; River São Francisco; Semiarid

Assessment of heavy metal fluxes in a forest watershed in Basque Country (Northen Spain) using SWAT model

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Abstract

Heavy metals contamination in rivers is more and more important. Dynamic of metals is very complex as depend on physical transfer and physico-chemical processes. One way to study and quantify the transfer of metals is by coupling modelling and measurements to put in evidence key processes involved in the contamination of surface water and sediment associated. The study focuses on the Oka River basin that has its mouth is in the Urdaibai estuary. It is the main contributor of continental water and sediment to the estuary. In 1984, UNESCO designated Urdaibai a biosphere reserve due to its ecological wealth, calling it the Urdaibai Biosphere Reserve.

The water quality of the river is subject to risks of contamination along the different hydrological periods. During these, they may have fast increases in the concentration of certain contaminants in water, as heavy metals that contribute to the degradation in quality. This may occur as a consequence of sediment resuspension in flood events.

The main objective of this work is to apply the SWAT model in the Oka River watershed (31 km^2) during eleven hydrological years (2001-2009 for validation and 2009-2012 for calibration), in order to quantify annual heavy metal fluxes associated with suspended solids.

The model has been calibrated using data of discharge (Q) and suspended sediment concentration (SSC). The efficiency criteria (R^2: Coefficient of determination and d: index of agreement) results were acceptable at daily time step: Q: R^2=0.71, d=0.92 and SSC: R^2=0.28, d=0.70. Based on linear regressions between SSC and particulate heavy metal concentration, it is possible to compute from simulated SSC data the element pollutant load transported. The results (kg/km^2/year) show that 11.901 of Zn, 4.145 of Cr, 3.144 of Pb and 1.668 of Cu are transferred at the outlet of the watershed.

Keywords

Heavy metal fluxes, Suspended Sediment Concentration, SWAT, Oka catchment

Comparative analysis of physical parameters sensitivity in two different geomorphologically watershed, Rio de Janeiro, Brazil

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Abstract

The analysis of physical parameters sensitivity evaluates which and how the final response of simulated flow is influenced by different parameters (WHITE & CHAUBEY, 2005; CIBIN et al, 2010). The identification of these sensitive parameters is usually used to proceed with the calibration of SWAT model that corresponds in setting values adjust with the objective to compare the interest results provided with measured data until an objective function is reached (WHITE & CHAUBEY, 2005). In order to assess the model's behavior in the flow simulation, this paper proposes the comparison and evaluation of parameters sensitivity in two distinct geomorphological features small watersheds, both located in the State of Rio de Janeiro. These watershed steel have diferences in precipitation intensity and land use/land cover. Barro Branco's watershed is carachterized with small hills, deeper soils and average annual rainfall of 1.100 mm and Bonfim's watershed is carachterized as a mountaineous area with swallow soils, altitudes up to 2200 meters and average annual rainfall exceeding 1550 mm. However, the watersheds showed similar problems in parameters calibration. The analysis of parameters sensitivity in Barro Branco's watershed showed that half of edaphic parameters (SOL_AWC, CN2, SOL_K, SLOPE, CANMX and BLAI) interfere on runoff, hence the maximum flow of the basin. Bonfim's watershed analysis of sensitivities was applied in three sub-basins and CN2, ESCO, SOL_K and SOL_AWC were considered the most sensitive parameters. These parameters are directly related to the simulation of surface runoff and base flow. Abraham et. al. (2007) in their study on an African river basin, and Thampi et. al. (2010), in Indian basins, classified the CN2, SOL_AWC and the ESCO parameters as most important for generating runoff. Comparing the simulated flow before and after calibration of the analyzed watershed, the results showed an opposite behavior in the maximum and flow peaks. Before calibration, these maximum flow data were overestimated, after the calibration the model underestimated them. This behavioral change can be explained mainly by the parameters adjust of CN2, SOL_AWC and SOL_K, wich increased infiltration and soil water storage. The soil parameters sensitivity in SWAT model is already known in the literature, which suggests a calibration routine to be adopted. In the watershed analyzed was observed that the sensitivity of these parameters was not related to the watershed physical characterization.

Assessment of climate change effects in a Mediterranean basin with different hydrologic models

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Abstract

The evaluation of the hydrologic impacts of climate change is a challenging topic due to the uncertainties present in its different phases. The difficulties are exacerbated in Mediterranean basins which are characterized by high variations in precipitation and by complex hydrologic responses. The Climate Induced Changes on the Hydrology of Mediterranean Basins (CLIMB) is a research project funded by the EU FP7 to assess the effects of climate changes in several catchments located in the Mediterranean area and reduce the related uncertainties. In the context of this project, we compare the results of three different hydrologic models in one of its study cases, the Rio Mannu at Monastir basin (473 km^2), a medium size basin located in an agricultural area of southern Sardinia, Italy. The models are the Soil and Water Assessment tool (SWAT), the TIN-based Real time Integrated Basin Simulator (tRIBS) and the Water Flow and Balance Simulation Model (WASIM). They are all distributed hydrologic models that differ in terms of terrain representation, representation of physical processes, level of conceptualization, and data requirements. The models were first independently calibrated and validated and, then, applied in cascade to climate models with the aim of evaluating the effects of climate changes in the study area in a reference (1971-2000) and a future (2041-2070) period. Four combinations of global and regional climate models, selected as the best performing and bias corrected, were downscaled and used to force the hydrologic models. Several hydro-climatic indicators were computed from the time series and spatial maps produced by the models to quantify the change in the basin hydrologic response, focusing on both water balance and occurrence of extreme events. Notwithstanding the specificities, the three hydrologic tools respond to

reduced precipitations and increased temperatures, predicted by all the climate configurations, showing a basin future condition of more water shortages and, in some cases, intensified extremes. While confirming what is generally predicted for the Mediterranean area, our results permit quantifying the uncertainty associated with hydrologic simulations involved in impact studies of future climate change.

Keywords

Mediterranean basin, climate change, hydrologic models, comparison

Effects of Global and Measured Weather Datasets on Amazon Basin Streamflow SWAT simulation

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Abstract

The understanding of the physical process of the hydrological cycle in Amazonia watershed is an important part of hydrology current research efforts. The Amazonia watershed has an area of approximately 6 million km[2] and is one of the most biologically diverse regions worldwide, with critical and highly sensitive hydrologic resource that drains about 16% of the annual global river runoff. The watershed can be described as an area where the physical processes are modeled under the perspective of water resources management over regional planning. Despite these important hydrological conditions, the Amazonia Watershed has a low density of hydrological monitoring networks which may pose challenges for testing of hydrological models, such as SWAT. Thus this study proposes to model the hydrological cycle in Amazonia using SWAT and also to evaluate the response of two different weather datasets on streamflow, to try to understand if global and local datasets can both represent well the complex hydrological dynamic of this large watershed. The first weather dataset used is from observed daily data, available in the region, from 40 weather stations of the Brazilian National Meteorological Institute - INMET and 204 rainfall gage stations provided by the Brazilian National Water Agency - ANA. The second dataset tested was *from a global coupled model: NOAA's Climate Forecast System Reanalysis (CFSR).* The uncalibrated simulated streamflows, using these two different datasets were compared with measured flow at the station of Obidos, which is the closest to the mouth of the basin. The primary conclusion is that both datasets presented good results of trends when compared with observed data at Obidos station, although the best adjust was provided with the observed data from INMET and ANA.

Keywords

SWAT model, Amazon basin

Preliminary Hydrological Water Resources Assessment of CEGA-ERESMA-ADAJA watershed using SWAT model

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Abstract

In the hydrologic assessment of water bodies, modelling is an important tool in developing water management strategies of watersheds. The SWAT model (Soil and Water Assessment Tool) was used to assess the hydrological response of the water management unit Cega-Eresma-Adaja (7,835 km^2), in the south of the Duero's river basin (Spain). The aim of this study is to obtain an accurate hydrological model of the catchment able to identify the current trade-offs between water and agriculture.

 A preliminary assessment on introducing the input information based on developed look-up tables defined by the user was carried out. The hydrological response units (HRUs) are defined in SWAT according to the land use, soils and slope classification. Therefore, the Land Cover and Use Information System of Spain (SIOSE) combined with agricultural statistical information were used to build a simplified look-up table with 15 SWAT land use codes. The European Soil Data Base (ESDB) was used for soils classification resulting in 13 soil types. Pedotransfer functions were applied to determine the hydraulic conductivity associated with each soil layer. Moreover, the terrain slope was reclassified from a 10m x 10m digital elevation model (DEM) and combined into 5 slope groups. Monthly data of precipitation and potential evapotranspiration from the SIMPA model at 1km x 1km grid resolution were used as weather input data. The model was calibrated using meteorological and river flow data from 1991 to 1998 and validated with data from 1999 to 2006.

The results obtained were satisfactory for all the 3 rivers, with a reasonable agreement between the model river flow simulations and observed data. Future research aimed to enhance the accuracy of the model simulating the interaction between surface and groundwater will be developed. The resulting model will be finally used to simulate future scenarios of land use and climate change evaluating impact on the local water resource in terms of quantity and quality.

Keywords

Cega-Eresma-Adaja watershed, SWAT, hydrological model, SIOSE, ESDB.

Glyphosate concentration in the Basin of Monday River: Modeling of river transport with SWAT model

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Abstract

The Monday River is a tributary of the Paraná River, this watershed is located in the Eastern Region of Paraguay, between the departments of Alto Paraná and Caaguazú. It has an area of 6,659 square kilometers, the average elevation is 260 meters where clayey soils are predominant. The average annual rainfall is about 1,800 mm. All over the basin, urban centers are distributed discontinuously. Throughout the basin, extensive farming activity where the main crops are soybeans, corn and wheat, direct seeding with crop rotation system is observed, represented by 61% of the total area. On the crop management, pesticides are necessary, between them, it is used glyphosate in quantities between 8 to 10 kg per hectare annually. Using the SWAT model aims to determine the concentration of glyphosate in the basin of Monday, by determining the main sources and the dynamic of the pesticide all over the watershed and help to better manage the land use to reduce the glyphosate concentration in the river. .

Keywords

Monday River, Glyphosate, SWAT Model.

Long term environmental research in the ITAIPU Catchment: SWAT Simulation of Flow and Water Quality in the Carapa River Basin-Paraguay

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Abstract

Starting in 1982, since the filling of the ITAIPU Reservoir, quantity and water quality data have been collected in the Carapa River Basin (275.000Ha). Carapa is one of the largest sub basins of the Itaipu Basin and contributes the most in sediments, and is one of the HELP Basin of UNESCO. The Carapa River has a lotic regime and the land use is a mixture of agriculture (82.5%), forest (12.5%), pasture (4.69%), urban (0.01%), surface water (0.2%) and a sugar factory complex. Levels of nutrients and phytoplankton biomass have probably changed since the Itaipu Reservoir started on November 1982. Since 2000, stream flow and climatologic data were measured daily and complemented the data sets of the basin. Specific data were introduced in the Soil and Water Assessment Tool to: 1) simulate flow, nitrogen and phosphorous cycle in soil and water, 2) distribute pattern of flow, nutrients will be quantified at the outlet of the watershed entering the reservoir, 3) The trophic status will be determined and compared with previous studies done in the early years of the reservoir, and 4) to simulate water infiltration through and saturation above the soil. The aims of this work are: to show the calibration and validation, and assess nutrients management practices in the hydrologic context of soils. Model calibration will be done over 2000-2014 at the daily measurements for flow and a quarterly monthly for water quality constituents. Contact mail: *gossen@itaipu.gov.py

Keywords

Carapa basin, Itaipu reservoir, nutrient fluxes, Parana River, chlorophyll a.

Sediment yield modeling using SWAT model in the Cañete basin (Peru)

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Abstract

Soil erosion is a problem that plays an important role for water resources management in the Pacific region of Peru. The present study focuses in evaluating the performance and functionality of SWAT model in predicting sediment yield from 2000 to 2005, using daily meteorological and hydrological data and monthly sediment samples data in one station of the Cañete basin (Socsi hydrological station) in Peru.

Sediment yield process will be estimated for each HRU with the Modified Universal Soil Loss Equation (MUSLE) using SWAT model, discharge volume and peak rates will be estimated using the curve number method and modified rational method, respectively. Calibration and validation procedure of the model will be evaluated using statistical and graphical methods to evaluate the performance in simulating the runoff and sediment yield.

Keywords

Sediment, erosion, SWAT, Peru

Land use change impact on hydrology over Southern Peruvian Amazonas

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Abstract

The Madre de Dios basin (MDB) (62024 km^2), located in the Southern Peruvian Amazonas is covering 8.7% of Peru. MDB has a population growing rate of 3% in the 2013 - 2014 period tripling the national average according to Peruvian National Institute of Statistic and Informatics. The principal economic activity in this region is the gold mining (informal mining mostly) and services drive to this activity. This activity causes problems like deforestation, removal and massive earthworks and social conflicts.

The objective of this research is to evaluate the impact of land use changes on hydrology of the MDB. For this purpose we performed a semi-distributed physically based model SWAT using inputs of daily meteorological data provided by the National Meteorological and Hydrological Service of Peru (SENAMHI). Calibration and validation procedure will be performed with the Pastora hydrological station (discharge data) located at the outlet of the watershed from the 2004 to 2012. Then, we will simulate hypothetical scenarios of land use changes overall in the dominant class (forest) to evaluate its impact on hydrology.

Keywords

Hydrology, Land use, scenarios, SWAT, Peru

Evaluation of Climate Forecast System Reanalysis weather data driving hydrological model for the Yangtze River basin in China

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Abstract

It is difficult and time consuming to collect representative meteorological data for watershed modelling. However, hydrological modelling can benefit from the Climate Forecast System Reanalysis (CFSR) global meteorological dataset. In order to evaluate the applicability of CFSR weather data for large-scale watershed hydrological model, this study presents a method for using the CFSR global meteorological dataset to obtain historical weather data and demonstrates the application to modelling the hydrology of the third largest watersheds in the world: Yangtze River Basin. The weather data from CFSR are firstly validated by ground-based meteorological station (GMS) weather dataset. The precipitation and temperature from CFSR data were with reasonable accuracy compared to the data from GMS with the R^2 larger than 0.6 in Badong and Mianyang weather stations, which showed that the CFSR weather data provide the sufficient accuracy to assess the hydrology. We then establish the Soil and Water Analysis Tools (SWAT) driven by the weather data from GMS, From parameter calibration using the discharge data from the Cuntan, Yichang, Hankou and Datong hydrological gauge stations in the year 1981-1992, the results simulated with the GMS weather data are with the high R^2 and E_{NS}, which are larger than 0.85 while the validation period (1993-2002) with the R^2 and E_{NS} is larger than 0.81. The CFSR weather data were then applied to drive SWAT model for the Yangtze River basin firstly without any calibration, and the results were with lower accuracy comparing with the reality. The calibration and validation again were conducted eventually for the model driven by CFSR weather data. In the calibration period, the R^2 and E_{NS} can reach larger than 0.80, while they are larger than 0.68 in the validation period, though the R^2 of validation is only about 0.6 between precipitation from CFSR and GMS. The established SWAT model provides parameter adjustment to improve the accuracy of hydrology prediction. Although, it seem that the stream flow simulated with GMS weather data is much better than that simulated with CFSR weather data, the results simulated with CFSR weather data in fact are reasonably accepted. The CFSR provides a good data source for quickly establish SWAT model for hydrology prediction in the large-scale watershed. For both results of validation by GMS precipitation data and validation by stream flow simulated with them, the CFSR weather data presented a robust applicability to any other large area for hydrological modelling when the data are difficult to be obtained.

Keywords

Hydrological modelling, meteorological data, Climate Forecast System Reanalysis (CFSR), the Yangtze River basin, large basin

How hydrological descriptors from SWAT model may help to understand recent shifts in the distribution of the semi-aquatic mammal species Galemys pyrenaicus

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Abstract

To understand the influence of global change on species range shifts, climate change alone is frequently considered. However, in freshwater ecosystems, hydrology is a key driver of the ecology of aquatic species and is also known to be modified by global change. Despite this, hydrological descriptors are rarely accounted for in Species Distributions Models (SDMs), especially at large scales, due to the lack of detailed stream flow data. In this study, stream flow simulated by SWAT model applied in all the Pyreneans Mountains (French part 18 000 km^2) was included as an input variable in a consensus of SDMs along with topographic, hydrographic, climatic and land-cover descriptors to explain the distribution of the Pyrenean desman (*Galemys pyrenaicus*). Pyrenean desman is a threatened semi-aquatic mammal endemic to the Pyrenees Mountains and the Iberian Peninsula. Environmental descriptors were coupled with two species surveys: one historical survey was conducted during the 1985-1992 period and the current one between 2011 and 2013. This integrated modeling approach allows us to predict habitat suitability of the Pyrenean desman, for both historical and current periods and highlight its potential range shifts. We simulate stream flow using the hydrological Soil and Water Assessment Tool (SWAT) during two 10 years periods. Hence, stream flow was available with a good accuracy (e.g. mean rho ≥ 0.79 and mean R^2 ≥ 0.65) across the entire stream network of the French Pyrenees (>26 000 km) for both historic (1976-1985) and current (2002-2011) periods, and at a fine spatial resolution (discretization scale around 40 ha).

We showed that the distribution of the Pyrenean desman is mainly constrained by climatic and hydrological factors, emphasizing the importance of taking into account hydrology when SDMs are applied to aquatic species. We found also that the Pyrenean desman range has strongly contracted all over the French Pyrenees for the last 25 years. This observed range contraction was much higher than the one projected when including only land-use, climatic and hydrological changes that have occurred during the two time periods. This finding suggests that other drivers, such as stream local habitat or biotic interactions, may be interacting with climate, hydrology and land-use changes. Our results are quite alarming for the conservation of this endemic semi-aquatic mammal as changes in climate and hydrology may continue and intensify in future.

Keywords

Modeling sediment dynamic in the Amazon-Andean basin of the Ucayali River, using the SWAT model

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Abstract

Total suspended sediment load of the Ucayali river (350 000 Km^2, 13 500 m^3 s^{-1}) represents 35% of the total 850 Mt yr^{-1} delivered by the Amazon River to the Oceans (Martinez et al, 2009; Santini et al., 2014). In this major tributary of the most important fluvial system in the world, sediment production and routing are both controlled by a still active tectonic, a marked seasonality and the presence of two of the major cells of extreme precipitation on the Andean eastern flanks It results a highly complex sediment dynamic, with an Andean production assessed to be 520 Mt yr^{-1} and a strong sedimentation (around 220 Mt yr^{-1}) in the retro-foreland system. In the floodplain, important processes of erosion and remobilization (up to 13% of the total load) have been identified. Moreover, sand, silt and clay fluxes are decoupled (Santini et al., submitted). Consequently, classic sediment transport models are inappropriate to predict sediment load.

In this study, we use high resolution and accuracy discharge and sediment data of the HYBAM observatory (www.ore-hybam.org) in four conventional gauge stations and seven virtual stations (with HYBAM remote-sensing technics) within the Ucayali river basin. Running the SWAT model (Soils and Water Assessment Tools), we first expect to reproduce sediment dynamic and water fluxes at the Andean piedmont. By this way and for the first time ever, we will propose a physically based spatial distribution of erosion yields in the Andean range, allowing further complementary studies. Finally, we expect to improve the floodplain processes in the model (sediment production, deposition and remobilization) and the routing method using SWAT model. To that purpose, we will base our work on the diffusion wave equation and sediment transport models theory, adapting them to the super-size of the Amazon River basin.

Keywords

Ucayali River, Amazon River, Peru, sediment remobilization, SWAT, floodplain, HYBAM

A tool to evaluate the impact of nutrient inputs to the eutrophication of the Itaipu Reservoir (Paraguay shore) : A multi catchment approach by modelling using SWAT model.

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Abstract

The Itaipu reservoir is located in the Parana watershed (891 000 km2) in the border of Paraguay and Brazil in the Parana river (South-America) and lies over the world largest aquifer, the Guarani Aquifer System. In the last years, an increase of the agricultural activities in the catchment around the reservoir generated nutrients input to the reservoir. In this study, we propose to evaluate the inputs of nitrogen and phosphorous and associate production of chlorophyll a at the multi-catchment scale around the reservoir in the Paraguayan shore in order to quantify a) the amount of fluxes that entered the reservoir and b) put in evidence the main sources and c) analyse the key processes involved in nutrient fluxes. The transition between phosphorous limitation of Chlorophyll a and nitrogen limitation in the lotic and lentic zones will be examined using principal component analysis.

As a first work we will go on investigating for a forward application of the model to take into account the percolation through the aquifer, and both the land use and climate changes to evaluate the contribution of the Paraguayan multi-catchments to the future inputs of nutrients to the reservoir by evaluating BMP to reduce this inputs.

Keywords

Itaipu reservoir, nutrient fluxes, Parana river, chlorophyll a, Guarani Aquifer.

Long term environmental research in the ITAIPU Catchment : SWAT Simulation of Flow and Water Quality in the Carapa River Basin-Paraguay.

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Abstract

Starting in 1982, since the filling of the ITAIPU Reservoir, water quality, data have been collected in the Carapa River Basin (275.000Ha). Itaipu Reservoir lies over the world largest aquifer: Guarani System. Carapa is one of the largest sub basins of the Itaipu Basin and contributes the most in sediments, and is one of the HELP Basin of UNESCO. Carapa has a lotic regime and the land use is a mixture of agriculture (82,5%), forest (12.5%), pasture (4,69%), urban (0.01%), surface water (0,2%) and a sugar factory complex. Levels of nutrients and phytoplankton biomass have probably changed since the Itaipu Reservoir started on November 1982. Since 2000, stream flow and climatologic data were measured daily and complemented the data sets of the basin. Specific data were introduced in the Soil and Water Assessment Tool to: 1) simulate nitrogen and phosphorous cycle in soil and water, 2) The distribution pattern of nutrients and chlorophyll a measured from 2000 to 2014, will be determined, 3) The trophic status will be determined and compared with previous studies done in the early years of the reservoir, and 4) to simulate water infiltration through and saturation above the soil. The aims of this paper are: show the calibration and validation, and assess nutrients management practices in the hydrologic context of soils. Model calibration will be done over 2000-2014 at the daily measurements for flow and precipitation and a quarterly monthly for water quality constituents.

Keywords

Carapa basin, Itaipu reservoir, nutrient fluxes, Parana river, chlorophyll a

Combining interpolation of daily gauge and satellite rainfall data to evaluate an hydrological model (SWAT)

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Abstract

Andes suffers the limited availability of stations measuring precipitation. In this study, we compared different approaches to combine interpolation of precipitation data from measuring stations of the National Service of Meteorology and Hydrology of Peru (SENAMHI) and the spatial patterns of precipitation of satellite data (Tropical rainfall Measuring Mission TRMM 3B42RT and PERSIANN CCS). The study is held in the basin of the Vilcanota River (Southern Andes of Peru).

The efficiency of interpolation methods are evaluated using the cross-validation and the bias. Then, all these products are evaluated using the hydrological model SWAT (Soil and Water Assessment Tool) by comparing the results of the discharges simulated with measurements.

Calibration and validation procedure of the model will be evaluated using statistical and graphical methods to evaluate the performance in simulating the discharge in the outlet of the watershed (Km 105 hydrological station) for each one of the interpolation rainfall products.

Keywords

Hydrology, meteorological data, satellite rainfall, Peru, SWAT

Estimating groundwater recharge in post-mining and urban area using SWAT and FEFLOW models, case study from Poland.

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Abstract

Groundwater recharge is crucial for assessing, protecting and managing groundwater resources and can be estimated using numerous mathematical models. In the presented study watershed (SWAT) and groundwater (FEFLOW) models were applied in order to asses groundwater recharge in the city of Tarnowskie Góry, southern Poland.

Tarnowskie Góry is an area heavily transformed due to the ore mining and heavy industry. Impact of these activities caused irreversible changes in the quantity and quality of the groundwater resources beneath the city. The Triassic carbonate aquifer system is abundant reservoir of strategic importance. It is used as a primary source of drinking water supplying inhabitants of the western part of the Upper Silesian Industrial Region. Therefore, reliable information about the groundwater recharge were essential for the correct estimation of the renewable resources.

By means of SWAT, influences of land cover and meteorological conditions on groundwater recharge were estimated. Moreover SWAT provided information about the relationships between the groundwater recharge and the remaining elements of a hydrologic cycle that were used at the FEFLOW model development stage. Simulated groundwater recharge was used as an input to FEFLOW model 1) directly in areas around Triassic outcrops and the places where the thickness of the permeable Quaternary layer lying directly over Triassic deposits does not exceed 10 metres and 2) indirectly in the remaining area for the model calibration as it provides data on maximum potential recharge.

FEFLOW model allows for much better representation of the groundwater component of hydrological cycle, especially where aquifer system is deeply transform due to human activity (urbanization and mining). The model, however, does not take into consideration the surface part of water cycle or simplify it too much. FEFLOW output highlights significant impact of post mining area on groundwater recharge due to increase of the permeability of rock mass and dewatering adits. Recharge in the area with the densest network of mining galleries is from 250 mm/year to 318 mm/year which was over 30 % of the total precipitation in 2010. Furthermore, a local artificial groundwater recharge occurs due to leakage from the water supply network estimated at 25-33 mm/year in the centre of Tarnowskie Góry.

The most important benefit from application of two different modelling techniques is significant reduction of the uncertainty in the simulation of groundwater recharge. This fundamental parameter in assessing groundwater resources has a great importance for the city of Tarnowskie Góry where groundwater is the only source of potable water.

Keywords

Groundwater recharge, post-mining areas, urban areas, SWAT model, FEFLOW model

Erosion and Runoff Evaluation using the SWAT-Terrace Model

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Abstract

Agricultural terraces are an effective conservation practice to reduce concentrated flow erosion. Researchers have simulated terrace effects using the Soil and Water Assessment Tool (SWAT) by adjusting the slope length and the USLE Practice P-factor. An algorithm was incorporated into SWAT (SWAT-Terrace; or SWAT-T), to better account of terrace benefits by simulating the effects of temporary storage of water. The objective of this work is to evaluate and validate SWAT-T by simulating the impacts of terraces on erosion and runoff for the 72 km^2 Goodwater Creek Experimental Watershed (GCEW) at watershed and Hydrologic Response Unit (HRU) scales. The GCEW is located in Boone and Audrain counties of north-central Missouri. The GCEW consists of mainly claypan soils, which have high erodibility and runoff that contribute to high sediment transport. Between 1990 and 2006, about 13% of GCEW was terraced, with most of these terraces being located in one 19 km^2 sub-basin. Discharge and sediment data that were collected at the watershed outlet from 1993-2010 were used to calibrate and validate the model. Results from SWAT-T with terraces will be compared to simulated results obtained with SWAT-T without terraces, and also to measured data. Preliminary results at the HRU level show significant sediment reductions, with smaller significant runoff reductions. However, in some years, annual sediment transport increased during heavy rainfall periods when terraces might have been overtopped. Sediment and runoff results will be analyzed to identify terrace benefits as part of the validation work of the terrace model. The SWAT-T improvements will be useful for soil and water conservationists to better quantify terrace benefits.

Keywords

Erosion; Modeling; SWAT; Runoff; Terraces; Goodwater Creek Experimental Watershed

Assessment of the impact of land use and land cover change on runoff characteristics of Lake Chini Catchment (Malaysia) using SWAT: a preliminary study

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Abstract

We present preliminary results of a study which has been conducted to assess the hydrological impact of land use /land cover (LULC) and land management practices in the last three decades for the Tasik Chini catchment using the Soil and Water Assessment Tool (SWAT). The approach could be divided into two main phases: the LULC change assessment and the SWAT modelling. During the first step we integrated the use of multi-source and multi-resolution remote sensing, topographic and field-based datasets to quantify LULC changes within Lake Chini catchment. The analysis was performed by computer-aided visual interpretation for several years using freely available satellite imagery. An ad-hoc hierarchical nomenclature has been adopted and changes mapped by editing those vectors representing features which underwent LULC change prior 2014. Spatial and temporal changes were analysed by post-classification approach and validated by ground truth information.

The last part of this study focused on the use of SWAT to model the hydrological characteristics and its changes for the whole lake catchment. Besides LULC data, daily meteorological data (rainfall, temperature, humidity, flow and solar radiation), soil (ISRIC SoilGrid1km) and elevation information (from available topographic maps) were used as input. Hydrological data together with traditional and modern land management practices (including planting, harvest, tillage operations, pesticide and fertilizer application) have been taken into account during modelling. Results showed how land uses rapidly shifted from natural forested land into economic based uses like oil palm and rubber monoculture plantations, intensive agriculture and mining. Tourist development and related growth of recreational facilities has been also mapped which, although not extensively developed, had a relevant environmental impact. These changes led to a modified hydrological system of the whole catchment showing how the superficial runoff and flow water discharge increased during the investigated period.

Keywords

Landscape, agricultural diversification sustainability

Estimation of Input Parameters of
SWAT Model Through Geoprocessing

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Abstract

Studies concerning the water resources are of great importance for the development of a society. Hydrological models are useful tools to aid understanding of the processes occurring in a watershed. Among the existing models, the SWAT have been widely used around the world and the successful implementation of the model depends in large part on the representativeness of the parameters used as input. Within this context, the objective was to estimate the soil average available water capacity of the Watershed Mundaú River, which is an input parameter for hydrological modeling of SWAT, from maps of soil types generated with the use of tools GIS. The study was conducted in the watershed of Mundaú River, northeastern Brazil. The map types basin soil was constructed from data obtained by EMBRAPA. To estimate the available water capacity was used an equation that considers the fractions and bulk density for the calculation of the parameter. The estimated average value of the available water capacity (AWC) Watershed Mundaú River, according to soil types, was equal to 5.45%. The geoprocessing tools combined with the GIS allowed the estimation of the SWAT model input parameters is of great importance to support the hydrological modeling.

Keywords

Watershed, available water capacity (AWC), modeling

Searching for synergies in crop rotation management – A simulation-optimization approach using SWAT

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Abstract

Climate change is expected to have severe impacts on agricultural and cropping systems. Changes in strategies for the management of land, resources and crop rotations are one way to adapt to future climatic conditions including land-use change and local adjustments of agricultural practices. Since the agro-ecosystem is an interconnected system where management interventions have multiple effects on a wide range of ecosystem services with the possibility to create both trade-offs and synergies between them. In this project, we investigate in a case study region in Western Switzerland how crop rotation management can best be adapted at the local and regional scale in order to increase the resilience of arable production systems towards more frequent climate extremes while promoting synergies with other ecosystem services (i.e. water regulation, soil regulation, carbon sequestration) and biodiversity conservation.

For this purpose a simulation-optimization approach is applied based on the semi-lumped conceptual biophysical model SWAT (Soil and Water Assessment Tool). Work tasks involve parameterization, calibration and validation of the model, as well as model evaluation analysis using sensitivity and uncertainty analyses with particular emphasis on parameters determining the ecosystem services under investigation.

The simulation-optimization model will be applied both at the site-scale and at the catchment-scale to identify management recommendations for strengthening synergies in agricultural management across multiple scales.

Keywords

crop rotation management, optimization, calibration, validation, climate change, SWAT

Modeling of the hydrology and nitrogen fluxes in a regulated semi-arid catchment using SWAT model: TheTafna River (North-West Algeria)

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Abstract

Water in Algeria is an increasingly invaluable resource due to high competition between agriculture, industry and drinking water supply, accentuated by a drought conditions in a semi-arid climate.

For a few decades, the demographic explosion, the development of agriculture and industry, have modified the water fluxes water infrastructures (dams) and biogeochemical cycle of nitrogen towards an increased production of nitrates in waters. In this context, modeling water and nitrates in surface waters appear to be essential, for understanding the mechanisms of nitrogen fluxes, and thus determining the zones and the periods of the year presenting a risk to polluted surface waters. Nitrogen retention was also studied in Tafna wadi downstream from a heavily polluted reservoir, to understand the role of the hyporheic zone in nitrogen dynamics. The results demonstrate the importance of the hyporheic zone in altering dissolved inorganic nitrogen composition and concentrations of heavily polluted arid streams.

The main aim of this study is to evaluate the impact of agricultural practices and water management on the quality of surface waters, especially nitrogen fluxes in the Tafna watershed (7200 km^2) The historical fluxes and meteorological data for 14 years(2000 to 2013), and monthly data (between 2003 and August 2011) on nitrogen flux is used to calibrate and validate the model. We will present the first results of SWAT application in the Tafna River to quantify the sources of pollution, the role of each compartment of the system involved in nitrates transfer and including the dams functioning.

Keywords

Nitrogen fluxes, Discharge, SWAT, Tafna wadi.

Overview of recent SWAT development at Temple, TX

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Abstract

Over the past 20 years, SWAT has been applied in many watersheds across the globe. The model has been modified and enhanced by several users, which made it increasingly difficult to maintain. Also, today's rising environmental awareness and the urgent need for governments and stakeholders to address water quantity and quality issues in the context of global change, is posing new challenges for hydrologic modelers and models. In order to facilitate model maintenance and make the model more flexible in terms of interactions of spatial units and processes occurring in a watershed, the SWAT code has undergone major modifications over the past few years. Currently, the new modular SWAT code and input files are tested extensively in several watersheds across the United States.

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

- the new modular SWAT code and input file structure,
- the datasets used to test and debug the new codes and input files,
- the integration of landscape units in the model to better account for routing processes across the landscape,
- the increased flexibility in terms of spatial interactions within the watershed and
- the tools that are currently available to set up and edit SWAT models using the new modular code.

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

Impacts of Spatial and Temporal Rainfall Variability in Water Balance in Watershed of the Paraiba State-Brasil

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Abstract

The need for rationalization in use of water resources, in the semiarid area of the northeast of Brazil, requires an understanding of interactions among climate. Due importance of an adequate water resources management, this study examines impacts of spatial and temporal rainfall variability in water balance of the Caraúbas watershed, in annual scale. The catchment area in study is great importance for the water resources of the Paraiba state. In this study, were utilized rainfall data of the 23 stations in basin, period of 1970 to 1990. The model utilized was based on identification and quantification of hydrological processes in two different sceneries. The first scenery was considered that the basin not have climate variation (rainfall and evaporation) and too not have soil variation. The second scenery was considered that the basin not have soil variation but have climate variation. According with the two scenery, when considered climate variation, the results estimated is similar with the observed data. The Nash coefficient and the coefficient of determination were on the average, 0,80 and 0,85, respectively. We conclude that it is important that climate data have been reliable and is not has defective, and the data represent the spatial area and temporally. Therefore, the model will have good performance. If the climate change is real we have very impacts in water resources.

Keywords

Water balance, superficial drainage, rainfall variation, semiarid.

Impacts of Spatial Variation of Soil in Water Balance of Watershed of Paraiba State-Brasil

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Abstract

The knowledge of spatial variation of physical characterization of soils is great importance to better monitoring and planning of water resources. The soils are natural dam that reserve water and serve to control and regularization of runoff. The world has passed for hydro shortage, in Brazil not have been different. We are passing for large hydrology dry. This dry not have relationship with climatology dry and yes with human change in soil. This change can to cause impacts in natural water dam (soils). This study has objective to evaluate the impacts of spatial variations of physical characterization of soil (depth and porosity) in water balance. The model was applied to Caraúbas basin, Paraiba river, in Paraíba state. The structure of model used here is simple and applied in month scale. The scenery to analyze was: vegetal cover interception is 10% of rainfall, rainfall and evaporation are homogeneous spatially and spatial variation of soils (depth and porosity). An decrease of 40% in depth of soil promote increase 65% in runoff. An decrease of 50% in porosity of soil promote increase 80% in runoff. Therefore, in watershed that was changing due human actions, urban development and waterproofing change spatial variation of physical characterization (depth and porosity) of soil. This cause impacts in water quantify in surface of the land. In special in semiarid basin, because is area very susceptible the hydro shortage. Know that the increase in runoff occurs due decrease in subsurface runoff or decrease natural water dam (soils). Therefore, after human change in land uses are need the creation of artificial dam to decrease of impacts of human actions about the surface water available to populations.

Keywords

soil variation, dam, subsurface runoff, semiarid.

Improving the spatial representation of soil properties and hydrology using topographically derived initialization processes by invoking a data brokering system

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Abstract

Watershed planners and managers need reliable tools that can capture the spatial and temporal complexity of agricultural landscapes, and water quality models are increasingly relied upon to represent agricultural watersheds. While a significant amount of modeling work has attempted to characterize field scale processes in watershed scale models, these models still typically require significant calibration and are thus difficult to apply meaningfully in areas without copious data with which to calibrate. This is partially because these models were never really intended as field scale tools, while we are trying to use them to define different hydrologic pathways, area weighted potential energy (slopes and saturated conductivities), and the resulting lag time of chemistry in different transport states. The movement of water within the landscape as surface (or near-surface) storm runoff and interflow is driven by gravity, topography, contributing area and soil and landuse characteristics, which play roles in concentrating water flows. Soil surveys have played a key role in the development of pedology and spatially derived pedon soil maps have become valuable datasets for natural resource management. Unfortunately, the soil surveys, commonly available at 1:20,000 scale, are not designed to provide the high-resolution models of the soil continuum required in field scale environmental modeling applications and site specific crop and water quality management. The goal of this project is to test repeatable brokering based initialization methods to incorporate topographic attributes, and resulting spatially explicit soil morphology that are missing from standard basin scale model initializations.

Keywords

Toporgraphy, BCube, Soil properties, Pedology

Coupling the Short-Term Global Forecast System Weather Data with Disturbed Watershed Models: Implication for Landscape Management

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Abstract

Many modeling tools exist for quantifying NPS pollution in watersheds. Unfortunately, these models are often used to study past events, and few tools are designed to identify short-term future high-risk runoff areas. Of these models, the Soil and Water Assessment Tool (SWAT) is one of the most widely used. This study introduces Future-SWAT (F-SWAT), a modeling framework designed to predict both hydrographic and distributed hydrology outputs at a daily time step. F-SWAT is based on the SWAT-VSA model framework that uses terrain-based metrics to drive runoff generation and soil moisture distribution. F-SWAT uses historical, real-time, and forecast weather data from a coupling of the Climate Forecast System Reanalysis (CFSR) model and the Global Forecast System (GFS) model as inputs to a SWAT model, allowing model runs up to 8 days in the future. F-SWAT was used to predict stream flow and distributed runoff in the South Fork of the Shenandoah river watershed in the Appalachian region of Virginia. Forecasted daily stream flow from predicted weather data were compared against measured stream flow from United States Geological Survey (USGS) gauge stations. Daily flow forecasts were found to be satisfactory up to four days into the future according to widely used forecast accuracy metrics. In addition, distributed runoff was provided for days with accurate flow forecasts. F-SWAT can provide landowners with valuable NPS forecast information that can be used to improve the effectiveness and efficiency of agricultural practices while reducing the risk of NPS pollution.

Keywords

Soil water assessment tool swat global forecast short-term variable source areas vsa land management F-SWAT SWAT-VSA real-time

Impacts of deforestation on water balance components of a watershed on the Silesian Beskid

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Abstract

In recent years, as a result of the impact of biotic and abiotic factors of the forest, there was an intensive process of deforestation in Western Beskids. In some areas of mountain catchments drastically reduced of forest surface, locally this reduction is over 50%. These changes are mainly observed in the retention disorders and hydrologic regime instability. The purpose of this study was an evaluation of the impacts of deforestation on the main water balance components of the Zimnik watershed, in the Silesian Beskid, on the southern part of Poland. The Soil and Water Assessment Tool (SWAT) model was used in this investigations. A physically based distributed hydrologic model, to assess the impact of deforestation and climate changes separately. The model was calibrated and validated for monthly streamflow. To assess the separate effect of forest cover and climate change we simulated streamflow under two scenarios with different combinations of climate data and forest surface indices. For analysis two periods were chosen, first from 2001 to 2004 when the drainage area was covered with forest and second, from 2010 to 2014 after decay of spruce stands. Pluvial variability increased the surface water and streamflow and decreased evapotranspiration. The analysis confirmed that the rate of changes of forest cover played a dominant role in this watershed water balance. The impacts of climate variability on hydrological processes revealed that the additional impact in streamflow is because the effects of deforestation on hydrological processes were enhanced by the effects of weather.

Keywords

Climate change, deforestation, Western Beskids, SWAT

Comparing SWAT and InVEST models for water yield estimation in two mountain regions

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Abstract

Mountain ecosystems offer a wide range of services that significantly impact nature as well as inhabitants and downstream communities. Over the years, ecosystem services have captured a great deal of attention in general, but relatively less so in mountain basins. Numerous tools have been applied to quantify the value of ecosystems and there is an increasing demand for understanding their contribution to society. In this research we investigate two commonly used tools for assessing water yield in two mountain basins located in Europe and South America. The Soil and Water Assessment Tool (SWAT) and the Integrated Valuation of Environmental Services and Tradeoffs (InVEST) model are used for simulating annual water yields. Sub-basin division was performed in a homogeneous manner and the inputs were used from similar sources (primarily free datasets). We discussed each model's strengths and weaknesses regarding spatiotemporal variability (e.g. time steps, spatial resolution, etc.). Along with the structure of the models, we discussed calibration, sensitivity, and parameter estimation of the models. Results are provided as a function of annual average water yield and ranking of the water yield of sub-basins. Despite their differing concepts, both the models can produce a substantial match with the observations. Nonetheless, uncertainties are also significant. Our results can help to understand the question of 'when do we need what kind of model' considering the data availability, accessibility and accuracy for valuation of mountain ecosystem services.

Keywords

Ecosystem Services, SWAT, InVEST

Improved Solution Methods for Instream Water Quality Simulations in SWAT

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Abstract

Computer models play an important role in addressing water quality problems. Planning activities for improving the water quality status of a river often involve scenario investigations and long-term statistical information and thus require numerous model runs. Since hydrologic water quality models have the advantage of computational efficiency over the detailed physically based water quality models, they are often preferable for activities involving multiple model runs. However, the accuracy and reliability of hydrological water quality models for scenario investigations might be compromised by their simplified representation of the physical processes. The solution technique used to solve the ordinary differential equations of hydrological models might further increase the model errors and hence the model uncertainty.

This paper presents an improvement of the solution technique used by the widely applied SWAT (Soil and Water Assessment Tool) simulator for the instream water quality processes. SWAT uses the Euler's numerical integration method to solve the differential equations of QUAL2E transformation equations. We analyzed the behavior of the SWAT solutions of the instream water quality processes for default parameter values as well as after appreciable calibration efforts for a case study of the Zenne River in Belgium. It turned out that SWAT overestimates the pollutant transformations and hence the results become unstable for large residence times. This is due to the fact that the accuracy of Euler's numerical solution is significantly affected when the pollutant residence time is large and the decay rate of the pollutant is high. Whenever the product of the residence time and the decay rate of a pollutant is bigger than unity, the transformed mass becomes greater than the pollutant mass available in the reach. This leads to negative concentrations, which the simulator simply sets to zero. This unreasonable and unstable solution reduces the reliability of instream water quality simulation, especially for low flow conditions in rivers with very mild slopes.

To improve the reliability of the instream water quality simulation results under all conditions, we replaced the Euler numerical solution method by a quasi-analytical solution procedure based on valid assumptions. The improved solution approach considers simultaneous mixing and transformation, based on the mass balance equations of the pollutants and on the assumption of an unsteady CSTR in a given reach. We compared the simulation results from the improved solution technique with the Euler method used by the original SWAT simulator, as well as with advanced numerical integration techniques that use a fourth order Runge Kuta method. We tested the stability of the solutions from the improved quasi-analytical method for real simulations and for hypothetical extreme low flow scenarios. Unlike the Euler method, the new quasi-analytical solution provides an

unconditionally stable solution, without compromising the computation speed of SWAT, even when advanced implicit fourth order Rung-Kuta schemes give unstable results. For the high flow periods, the original method used by SWAT gives similar results with the improved quasi-analytical solution technique. Water quality processes are often critical during the low flow periods and hence it is fair to conclude that the improved solution approach is advantageous over the original Euler solution method used by SWAT to represent the instream water quality processes.

Keywords

water quality, modelling, analytical solution, qual2e, conceptual modelling

Imputation for Missing Baseflows using the SWAT and Machine Learning Models in Taehwa River, Korea

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Abstract

Hydrologic model always requires observed data input to calibrate parameters and assess the model. However, field sensors sometimes fail, making the given observed data unreliable with abnormalities or missing values. Those data can cause incorrect model response but, it is also inappropriate to simply ignore them if there is limited data. To resolve these problems, data imputation can be used, which replaces incorrect and missing values in the dataset with probable ones. In this research, Samho gauging station in Taehwa River (TR) had sensor faults from 2004 to 2006 with constant signals for base flow. However, there is no substitute for flow data in TR during that period thus; it is necessary to recover base flow information. To estimate base flow, this study employed Soil and Water Assessment Tool (SWAT) and two machine learning techniques, Artificial Neural Network (ANN) and Self Organizing Map (SOM), using relatively reasonable flow data sets from 2004 to 2009 in Samho station. SWAT calculates base flow by its governing equations, while machine learning methods rely on relationship between input and output. Additionally, ANN and SOM are distinguished as supervised and unsupervised learning hence; we can assess three imputation methods by comparing each result. We selected daily precipitation, daily mean temperature, total rainfall of previous 5 days, and mean temperature over previous 10 days as input variables of ANN and SOM. Performance of three methods showed similar trends however, only ANN overestimated imputed values of base flow compared to the observed data while the others had lower estimation. This study expected to increase data efficiency and it can be explored further with different methodologies and data sets.

Simulating pesticide transport to tile drains via macropores using the SWAT model

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Abstract

Preferential flow and colloidal facilitated transport via macopores connected to tile drains are the main pathways for pesticide transport from agricultural areas to surface waters in some area. We developed a macropore flow module and a sediment transport module for the Soil and Water Assessment Tool (SWAT) to simulate transport of both mobile (e.g. MCPA) and strongly sorbed (e.g. Terbuthylazin) pesticides in tile drains. Macropore flow is initiated when soil water content exceeds a threshold and rainfall intensity exceeds infiltration capacity. The amount of macropore flow is calculated as a fraction of effective rainfall and transported to the tile drains directly. Macropore sediment transport is calculated similarly to the MACRO model (Jarvis et al., 1999). Mobile pesticide transport is calculated with a decay function with the flow, whereas sorbed pesticides transport is associated to macropore sediment transport. Simulated tile drain discharge, sediment and pesticide loads are calibrated against data from intensively monitored tile-drained fields and streams in Denmark.

Keywords

Pesticide, macropore flow, MACRO, tile drain, sediment, MCPA, Terbuthylazin

Evaluation of the impact of organic farming and climate change on water quality in a tea planting reservoir watershed of Taiwan

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Abstract

Water security and scarcity have become an important environmental issue as climate change impact is getting more severe. Although 3-4 typhoons annually invade Taiwan during May and October and contribute ~30-60% of annual rainfall (2,500-3,000 mm), only ~20% of annual rainwater could be retained. Hence, in Taiwan reservoirs play an important role in water resource management to provide sufficient water quantity among wet and dry seasons and acceptable water quality for the residents. With an increasing demand for land, farming activities have expanded to the reservoir watershed, leading to eutrophication and sedimentation in the reservoir. Therefore, we investigate the agricultural management in the Feistui Reservoir watershed, which is now experiencing a transition from traditional tea plantation to organic farming practices. The Feitsui Reservoir is one of the most important reservoirs, providing hydro-power and daily domestic water use of 3,450,000 m^3 for 3.46 million people in Taipei, Taiwan. In this study, we applied the SWAT (Soil and Water Assessment Tool) model with future climate change scenarios derived from General Circulation Models (GCMs) to assess the impact of climate change and organic farming on watershed responses. The results showed that the annual streamflow, total suspended sediment (TSS), total nitrogen (TN) and total phosphorus (TP) tend to increase by 3.1 – 7.4%, 14.6 – 76.6%, 1.5 – 5.9% and 1.1 – 47.8% under the worst climate change condition (gfdl_cm2_1-B1). Organic farming had positive impact on improving water quality, especially in the upstream watershed. The evaluation of the spatial and temporal variation of the watershed responses under climate change could be useful for promoting efficient organic farming in the watershed.

Keywords

Organic farming, watershed planning, climate change, SWAT

A Heavy Metal Module Coupled in SWAT Model and Its Application in Liuyang River Upstream Basin in China

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Abstract

Mining may cause severe heavy metal pollution to the waters and soil nearby, which entails the understanding of the rule of migration and transformation of heavy metals in a mining watershed. Generally, the transport of heavy metal can be categorized into two types: vertical and lateral migration. Vertical migration refers to the process of heavy metal in percolation moving downward to pollute deep soil and underground water. Later migration means the horizontal transport of the heavy metal along with soil erosion, surface runoff, interflow and underground runoff processes. Up till the present moment, very few researches have been conducted to investigate the lateral transfer of heavy metals because of the difficulty to coupling the water/sediment movement with the heavy metals' movement. The Soil and Water Assessment Tool (SWAT) model is a well-developed hydrological model which has been proved to be successful to model the non-point source pollution such as nitrogen and phosphorus and pesticide, and hence been widely applied. However, as far as heavy metals is concerned, the SWAT model, by its own version, only allows point source loading inputs, which addresses a small part of heavy metal pollution issues. Making good use of the excellent capability of SWAT to model hydrological processes and non-point source pollutions, the author developed a heavy metal module which could be coupled with the SWAT model to show the movement of heavy metals. The heavy metal module is based on heavy metal polymorphic transformation kinetics in soil, but the cornerstone of the module relies on a hypothesis of quick equilibrium among different chemical species of a heavy metal. Usually heavy metal can have four chemical species: labile species and non-labile species in solid phase, free ion species and ligand-bound species in aqueous phase, and the hypothesis of quick equilibrium in the heavy metal module assumed that the species always maintains an equilibrium at hydrological time resolution adopted in SWAT. The SWAT model coupled with the heavy metal module was used to simulate zinc (Zn) dynamics in Liuyang river upstream watershed from year 2008 to 2014, where a Zn ore mining has been active. Filed monitoring has indicated that the average concentration of Zn in the soil around the mining area is 800 mg/kg, which is much higher than the background value of local soil, 157 mg/kg. Sampling in the downstream

of mining area showed that the aqueous phase Zn concentration is beyond 1000 ug/L but the concentration could rise dramatically to thousands ug/L level after precipitation. This monitoring results strongly signified that Zn in the soil could be washed out to the water course through rainfall. By applying the SWAT model with our heavy metal module, integrated with meteorological, topographical, and land cover data, the evolution of Zn in the Liuyang River upstream has been represented with fairly good agreement with the monitoring results. This initiative effort of developing a heavy metal module coupled with SWAT has strong potential to be applied in environmental risk analysis and pollution control.

Keywords

Heavy metal, SWAT, Non-point source, Mining, China

Land use and land cover change in mountainous watersheds: Consequences for ecosystem services of water yield and water quality

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Abstract

Mountainous landscapes provide a wide range of ecosystem services essential for the majority of the global population, most notably through the supply of clean fresh water from headwater catchments. Land use and land cover change (LUCC), however, has altered the capacity of those landscapes to regulate the hydrologic cycle and to control water pollution with substantial impacts on water yield and water quality in downstream areas. Mountainous landscapes of East Asia such as the Soyang Lake watershed in South Korea experienced dynamic land use and land cover changes in recent decades through deforestation, reforestation, agricultural expansion and contraction, and a steadily growing urbanization. Based on previous observations on land use and land cover change and its drivers, we developed a modeling framework that allows us to estimate the potential future land use and land cover in this watershed and to quantify the associated impacts on water related ecosystem services. Logistic regression embedded in a cellular automata (CA) model will predict the spatial configuration of major land use and land cover types such as forest, dryland agriculture, rice paddies, and urban zones for different development scenarios. The Soil and Water Assessment Tool (SWAT) will translate these changes into local management operations and associated biophysical processes and simulate water balance, streamflow, as well as sediment, nitrogen, and phosphorus losses. Using the SWAT output, we will be able to assess the watershed's capacity to sustain the provision of ecosystem services under the pressure of future land use and land cover change. We will present how different development scenarios will affect water provision, flood regulation, and the retention of sediment and nutrients due to changes in forest cover, agricultural land, and urbanization. Mountainous watersheds are highly vulnerable to degradation and small changes especially in headwater catchments and streams may cause substantial impacts to downstream beneficiaries of ecosystem services. Thus, prior assessment of potential land use and land cover change effects through future projections of development alternatives can guide land use policies and management planning to secure the sustainable supply of ecosystem resources and services.

Utilization of Soil and Water Assessment Tools in Indonesia

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Abstract

Soil and water assesment tool (SWAT) is a comprehensive, semi-distributed river basin model that requires large number of input parameters. This condition makes parameterization and calibration of the model complicated. Several calibration techniques have been developed for SWAT including manual and automated calibration procedures. Besides, there is SWAT-CUP with a decision making frame work incorporating a semi-automated approach (SUFI-2) and as well as sensitivity and uncertainty analysis. Parameter sensitivity analysis helps focus calibration and uncertainty analysis and is used to provide statistics for goodness-of-fit. Hundreds of peer-reviewed articles have been published that report SWAT applications, review of SWAT components, or other research that includes SWAT. However, in the mean time, in Indonesia, it is still difficult to identify a peer-reviewed published articles because of the difficulty to obtain valid data for the researchs. This study aimed to identify sensitive input parameters and calibration techniques according to Indonesian condition, especially West Java Province. Many articles in Indonesia (especially in West Java Province) were reviewed and summarized here according to relevant application categories such as pollutan load assessments, and sensitivity analysis and calibration techniques.

Keywords

Calibration technique, Indonesia, parameters, sensitivity analysis, SWAT

Diagnostic tools to understand hydrological processes in the SWAT model

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Abstract

The SWAT model helps to predict hydrological processes in a study catchment and their impact on river discharge. For reliable discharge predictions, a precise simulation of these hydrological processes in the SWAT model is required. Diagnostic model analysis allows a detailed investigation of the model structure and the model results. In this study, different diagnostic tools are combined with the aim to improve the process understanding of the SWAT model. For this, the Treene lowland catchment and the Upper Saale catchment in Germany are compared to analyze the applicability of the diagnostic tools in different landscapes.

The first diagnostic tool is a temporal resolved parameter sensitivity analysis. With this approach, dominant model parameters of the SWAT model and the corresponding processes are detected in a daily resolution. This analysis shows how the SWAT reproduce the process dynamics. Furthermore, it is required to analyse in the model calibration the different phases of the hydrograph in SWAT model studies. For this, the flow duration curve is subdivided into five segments and investigated for different timescales. By applying this diagnostic tool, all discharge conditions are included in the model calibration so that the same model can be applied for different research questions such as floods or droughts. Both diagnostic methods are jointly considered to detect the temporal dynamics of dominant parameters and corresponding processes for different discharge conditions. This results into characteristic patterns of the hydrological conditions in the study catchments. These typical process patterns lead to a better understanding of processes in the SWAT model.

Keywords

Sensitivity analysis, Model diagnostic analysis,

Advances in the modeling of Watershed and Riverine Fate and Transport of Contaminants

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Abstract

The fate and effects of contaminants in the environment has generated considerable public concerns at many locations and spatial scales. U.S. Department of Defense agencies are being tasked with analyzing contaminant fate and transport across large spatial domains with limited data availability. Contaminant source zones are distributed in nature with interactions taking place in overland regimes before they reach more concentrated flow areas (i.e. streams and rivers). Current distributed landscape models tend to be high fidelity with large computational requirements in addition to detailed data requirements. This limits the analysis to smaller drainage areas (i.e., 100 sq mi or less) and smaller time frames (less than a year). What is needed is a landscape model with less computational requirements that will allow one to spatially account for contaminants within the watershed, model large basins (greater than 500 sq mi), over large time frames (years), for complex contaminant kinetics (multi-phase),and can readily use national and global datasets. The U.S. Army Engineer Research and Development Center (ERDC) has developed the Contaminant Simulation Module (CSM) to assist in more accurately simulating contaminant fate and transport. CSM is a module that allows one to manage and remediate contaminated areas on military installations and ranges as well as superfund sites. The module allows for multi-species and multi-phase contaminants, thus it is able to handle chemicals as well as heavy metals. CSM has a modular, process-oriented structure so that it can be easily modified or extended and, furthermore, it can be used as a library of contaminant transport and transformation processes from which the user can select a sub-set of processes suitable for a particular application. CSM capabilities allow one to: 1) Assess soil, sediment and surface water for contaminated environments due to military activities; 2) Study the environmental impacts of other contaminants entering in watershed systems such as toxic chemicals, acid mine drainage, metals from mining areas, and the deposition of solid compounds from the atmosphere to the land surface; 3) Implement for installation compliance with water quality regulations as well as long-term watershed planning and management; and 4) Provide exposure assessment and risk management for sustained and future sustainable mission capacity for military installations. CSM features are: 1) Multi-species; 2) Multi-phase partitioning (dissolved, DOC bound, sediment sorbed, solid particles); 3) Channel and overland contaminant transport via flow and sediment; 4) Water column interaction with upper sediment/soil layer; and 5) Eight transformation processes (Biodegradation, Hydrolysis, Oxidation, Photolysis (Photodegradation), Volatilization, Dissolution of solid phase, User-defined extra reaction, and Transformations and daughter products). This paper will discuss the current CSM formulations and integration efforts being performed by ERDC for landscape and riverine modeling systems.

An automated procedure for SWAT-LUD to be applied at Catchment scale.

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Abstract

Modules representing exchanges between the river and its accompanying alluvial aquifer and biogeochemical processes in shallow aquifer of alluvial plain were developed. They were added to the SWAT model which is then called SWAT-LUD. It was applied at the floodplain scale and the results proved that the SWAT-LUD model could satisfactorily represent the water exchange and shallow aquifer denitrification processes. In a SWAT-LUD model, a new type of subbasin, named subbasin-LU, is implemented and a structure called Landscape Unit (LU) is applied. A subbasin-LU is delimited by the floodplain area and HRUs with alluvial soil are distributed into different LUs. To apply the SWAT-LUD model at the catchment scale, an automatic procedure was proposed to separate classic subbasins and subbasins-LU and to distribute alluvial HRUs to LUs.

To achieve this objective, a Fortran subroutine was developped taking Output files of the standard SWAT project (generated by ArcSWAT) and producing iutputs for the SWAT-LUD model. The algorithm includes different steps which are: 1) reading output files from an initial SWAT project; 2) distributing LUs according to flooded area for different return periods; 3) distributing alluvial HRUs into LUs based on their land use and slope. This automatic procedure is validated at the catchment scale of the Garonne catchment (55 000 km^2). All the steps of this automated procedure will be presented and efficient ways to build HRUs which fit into the Landscape Unit model will be discussed. .

Keywords

SWAT-LUD, Landscape Units, alluvial aquifer, river - aquifer exchanges, catchment scale, automated procedure

Comprehensive simulation of surface-subsurface hydrologic and water quality processes in watershed systems using linked SWAT-MODFLOW-RT3D model

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Abstract

Watershed models are frequently used to assess the impact of land management practices on water yields and agricultural chemical fate and transport in complex watersheds. For example, the Soil Water and Assessment Tool (SWAT) has been used extensively in watersheds worldwide for analysis of water resources and remediation of nutrient pollution in watersheds of varying scale and complexity. However, application of the model is limited in watersheds wherein streamflow is strongly affected by groundwater discharge, due to the simplistic implementation of groundwater flow and solute processes. In this study, the SWAT model is linked with the groundwater flow model MODFLOW and a groundwater solute reactive transport model RT3D (Reactive Transport in 3 Dimensions) to provide a watershed model that simulates not only land surface and in-stream hydrologic, biological, and nutrient processes, but also flow and reactive solute transport in the aquifer and groundwater-surface water interactions. Of particular importance is the ability of the model to predict spatially-variable water table elevation, groundwater discharge to streams, solute concentration in the saturated zone of the aquifer, and groundwater solute mass loading to streams. An application of the SWAT-MODFLOW-RT3D model to the Sprague River Watershed ($\sim$4,000 km^2) in southern Oregon, United States, also is presented, with stream discharge, reach-by-reach groundwater discharge to the stream network, and water table levels compared to observed field data. The subroutines used to transfer data between SWAT Hydrologic Response Units (HRUs) and the finite difference grid cells employed by MODFLOW and RT3D will be discussed, as well as the pre-processing code routines required to formulate this linkage. Future directions of the project, including a GIS-based user interface for SWAT-MODFLOW model development, also will be presented.

Simulation of Terrestrial Biomes and Ecoregions with SWAT

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Abstract

We propose a method to select vegetation (plant community) growth parameters needed for simulation of the water use, growth, and development of plant communities worldwide with current and future versions of the Soil and Water Assessment Tool. We propose to work with SWAT users worldwide to develop, test, and disseminate SWAT vegetation parameters for the 14 terrestrial biomes defined and described by World Wildlife Fund (WWF) (**http://www.worldwildlife.org/biomes**). These terrestrial biomes are located from sea level to the highest mountain ranges and from the most humid to the driest lands on earth, and they "follow complex patterns determined by climate, geology and the evolutionary history of the planet." WWF has also defined, described and mapped over 800 local, spatially referenced variants of these 14 terrestrial biomes called terrestrial ecoregions of the world (TEOW). By proposing specific SWAT2016 vegetation growth parameters for these 14 terrestrial biomes and selected TEOWs, we hope to stimulate the worldwide SWAT user community to develop, calibrate, validate, use, and share vegetation growth parameters for many of these TEOWs.

Keywords

Plant growth, soil and water assessment tool, terrestrial ecoregions, terrestrial biomes, world wildlife fund

Biofuel impacts on ecosystem services, biodiversity and human well-being – the contribution of SWAT modelling to integrated land use governance

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Abstract

Modern bioenergy has the potential to promote rural development and enhance food security[1], while reducing the environmental burden of the energy system and mitigate climate change. However, to do so, bioenergy needs to be produced sustainably to avoid undesirable impacts on the diversity and quality of natural ecosystems and on human well-being. Ensuring the sustainable production of biomass for bioenergy has thus become a key topic globally and the land-use impacts of bioenergy deployment are researched intensively[2]. In particular, solutions are being sought for the creation of working landscapes that balance agricultural intensification to feed 9.6 billion people by 2050, biomass production, biodiversity conservation and the provision of other ecosystem services[3]. A consensus is emerging that creating productive and healthy multi-functional landscapes requires the capacity to adequately assess environmental and socio-economic trade-offs in an integrative manner[4]. However, to date, neither governments nor academics have succeeded in developing appropriate analytical approaches able to facilitate this.

This presentation will provide an overview of the work carried out in the ILAMS project (Integrated Land Management Solutions for a Sustainable Bioeconomy) in which the impacts of biofuel production on land use, ecosystem services, biodiversity and human well-being are studied at a landscape level. The project provides an innovative way to measure and deal with trade-offs between the supply of bioenergy and the provision of other ecosystem services and biodiversity for human well-being. To this end, a land management toolkit based on a spatially explicit, dynamic model of ecosystem services, biodiversity and human well-being is has been developed. One of the key components of this model is the SWAT model and the presentation will illustrate the application of the SWAT for the governance of land use. A case study of the production of second generation ethanol in Portovesme (Sardinia) will be used to illustrate the model and its application.

Alternative uses of land generate trade-offs on ecosystem services, biodiversity and human well-being which need to be assessed and resolved to minimise the impacts of the intensification of agriculture. This project shows how stakeholders' views and values can be integrated with knowledge from the social and natural sciences through modelling to provide a tool able to advance biofuel systems which contribute to environmental quality and societal well-being.

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Keywords

Second generation ethanol, ecosystem services, integrated assessment, decision making

The effects of the short-term Brazilian sugarcane expansion in stream flow: Monte Mor basin case study

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Abstract

Land use change has the potential to affect the hydrological cycle, changing some processes such as infiltration, groundwater recharge and runoff. Hydrological models are widely used in water resources planning and management, allowing a satisfactory assessment of the resources dynamics in watersheds, as well as reliable information about systems behavior. This work aims to assess impacts of land use change driven by sugarcane expansion from 2007 to 2028 on a basin stream flow using the Soil and Water Assessment Tool (SWAT). The study area (Monte Mor basin) has 698 km^2 of drainage area and is located in a Brazilian traditional sugarcane production region, under *Cwa* climate classification (Köeppen). In this paper it was used the Brazilian Land Use Change Model (BLUM) bounded by basin physical parameters to estimate a predicted increase of 42% in sugarcane areas, representing only 2% of Monte Mor basin area, that would occur exclusively over pasture lands (FS1). Alternatively it was also evaluated a scenario in which all the pasture area (in sub-basins with sugarcane) were converted to sugarcane, representing 18% of the total basin area (FS2). Simulations were done on monthly time step from 1995 to 2007 with two years of model warm up. It was used a 1996 land use base map, using supervised classification method for Landsat satellite images, as well as land use change updates, which were made for four years (1999, 2001, 2004 and 2007). Rainfall data were collected from National Water Agency (ANA) in stations nearby the basin area. The other required meteorological elements were gotten from Global Weather Data. Stream flow time series for calibration and validation at the basin outlet point were taken from the São Paulo State Department of Water and Sewerage (DAEE). Calibration and validation were satisfactory, with Nash Sutcliffe (NS) values of 0.75 (Very Good) and 0.65 (Good), RMSE-Observations Standard Deviation Ratio (RSR) values of 0.50 (Very Good) and 0.59 (Good) and Percent Bias (PBIAS) of 12.2 (Good) and 19.5 (Satisfactory), respectively. For the whole period (1995-2007) the obtained NS was 0.70 (Good), RSR was 0.55 (Good) and PBIAS was 15.77 (Satisfactory). The validated model was applied for the scenarios and the monthly stream flow for the first period (1995 to 2007) was compared with the values of the second period (2016 to 2028). The PBIAS in case of FS1 is -1.3 and it is -3.5 in case of the second scenario. Although the differences are more significant in FS2, it is possible to conclude that in both considered sugarcane expansion scenarios the conversion of pasture lands does

not produce significant changes in Monte Mor basin stream flow, based on SWAT simulations. The procedure will be replicated to other two different Brazilian basins, in São Paulo State and Goiás State, both in relevant sugarcane expansion areas.

Keywords

Hydrological modeling, Sugarcane, Land Use Change, SWAT

Cloud Computing for Dynamically Creating Land Use Update file for SWAT

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Abstract

It is known that the Soil and Water Assessment Tool (SWAT) model from SWAT2009 version onwards has been provided with an optional landuse update file (filename lup.dat) that allows updating hydrologic response unit (HRU) fractions during model simulation runs. Through lup.dat file, it has been possible to represent land use changes over the entire simulation run or initialize conservation measures during a chosen period in the middle of simulation run, as per user defined specifications. Depending on the scale of studied watershed, carrying out manual updates for HRU fractions could be both time consuming and error prone. This paper presents the evolution of SWAT2009_LUC, a desktop based tool, into a cloud computing tool named SWAT_LUP for dynamically creating lup.dat file in an interactive manner.

The conceptual foundation of this paper and a demonstration of the tool will be emphasized. Test results from an urbanizing watershed in northwest Arkansas by using three temporal land use geospatial data layers acquired during 1999, 2004, and 2006 will also be presented. The results show that the land use distribution generated by the tool was consistent with the input land use layer for each year and was updated correctly during the model run. Overall, the results showed that activating the LUC module using the SWAT_LUP tool improves the spatial and temporal hydrological responses from the SWAT model.

Keywords

Cloud computing, land use change, hydrologic response unit, watershed

Combining digital soil mapping and hydrological modeling in a data scarce watershed in north-central Portugal

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Abstract

Data scarcity implies serious limitations to the use of eco-hydrological models supporting the decision making process and, in ultimate instance, may lead to inappropriate measures of integrated water resources management. Particularly the importance of spatial soil information is often overlooked. The forest-dominated Águeda catchment in north-central Portugal is such a region with serious data availability limitations. For a better understanding of the Águeda's water balance and its principal runoff generation processes, this study tests a novel method to overcome the shortage of spatial soil information. The Soil Land Inference Model (SoLIM) approach combined with soil surveys was used to create a map of soil properties, based upon the site potential soil depths. The constructed soil map allowed a better representation of the spatial distribution of potential plant available water. The Soil Water Assessment Tool (SWAT) was applied to the Águeda catchment with two input data sets differing in the soil profile data. Although SWAT performed satisfactorily in simulating daily streamflow for both data sets at the outlet, results of our study indicate that, with the SoLIM derived soil data set, a better representation of the first peak flow events after the dry period was achieved. Additionally, it is shown that the better representation of profile depth can contribute considerably to the understanding of water balance components at the small scale and for the implications for management. This study underlines the importance of spatially distributed soil information in watershed modeling for decision making in the river basin management process.

Keywords

Soil mapping, SoLIM, hydrological modeling, SWAT

Dynamics of Water Erosion of Bia Transboundary Watershed (Ghana-Cote D'ivoire)

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Abstract

Dam Ayamé 1, originally designed mainly for generating electricity, promotes fishing, drinking water and agriculture (development of nurseries and plantations around the lake). However, deforestation) and intense agricultural activities would favor erosion upstream of the reservoir. However, sediment transport that causes the nutrient intake accelerates the process of silting, siltation and eutrophication of lakes (N'go, 2000). In the light of these negative consequences, the phenomenon of erosion is of particular interest for the economic development of the countries (Raissouni, 2011). However, quantification of sediment yield in the watershed is still not easy, because of the temporal and spatial variability of the hydrological regime coupled with insufficient data available relating thereto. Only the modeling approach of erosion and sediment transport will better address them. Given the complexity of the phenomenon of water erosion in the watershed of the Bia linked to significant heterogeneity of soils, assaulted a canopy, and poorly distributed rainfall both in space and in time A mapping of the random variable test "specific erosion" is undertaken. The goal is to detect producing areas of sediments for an anti-erosion management for the preservation of Ayamé Dam. We obtained by superimposing maps slopes and soil occupation zones of potential erosion of the Bia basin. The mapping of the intensity of the hazard of erosion and the different types of erosion operation was performed using the universal soil loss model (USLE). The superposition of layers of information on rainfall, soils, topography and vegetation cover, provides a map which shows the average hazard of erosion in t / ha / year per spatial unit and produced a map synthetic distribution of degrees of sensitivity to erosion. The integration into GIS formulas of the universal soil loss equation has established the decisive factors that control water erosion are the slope, soil erodibility and vegetation cover. The resulting map shows that the Bia watershed suffered severe climatic aggressiveness with an average 1040 MJ mm (ha h year) -1. The weighted average value of K for the entire basin is 0.13 this confirms the high susceptibility of soils in the watershed of the Bia water erosion. Vegetation plays a protective role good enough for the majority of the Bia watershed since the value of C 0.35. Nearly 34.32% of the forest area is maintained by the parks and reserves. LS mean value in the pool was 3.3.

The most sensitive areas represent 189,41km² and can deliver up to 1631 t / ha / year of materials. At the watershed scale, 29.43 million tons of soil are potentially torn and are therefore likely to contribute to the dynamics of the flow of current sediment over a year. Indeed, the model does not take into account the transport process / sedimentation of materials, mainly dependent on the competence of the river. This estimate will not tell

in no way a prediction of flows to the lake, but the amount of information potentially available from the watershed materials and thus reveals his current alteration.

Keywords

Dam Ayamé 1 USLE, GIS, Water erosion, Bia, Ivory Coast

SIDRO: a Web-GIS interface for SWAT model

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Abstract

The SWAT (Soil and Water Assessment Tool) model data-structure is complex. Input/output data are organized in files that grows linearly with the number of subbasins and HRUs. One model can be made of thousands of files and it is difficult to make sense of it, if one does not possess specific advanced technical skills. Most of final users of SWAT do not have such knowledge.

The purpose of the SIDRO Web-GIS interface is to create a simple way to read and analyze such data using a web browser, in order to overcome the classical approach of using commercial desktop software (ArcMAP, Access) and read SWAT input/output in a very simple way. SWAT data has been pre-processed with the development of two software applications: SPRITE, which selects, extracts and transforms spatial and text/table data into a format compatible with the second software, SwatSL, which in turn creates an ordered data schema stored in a Spatialite database. Once stored in a database, data can be accessed using a web application through a typical client-server architecture based on open source technologies, like HTML, CSS, Javascript, SQL, jQuery and Bootstrap. The SIDRO web application was born to expose the SWAT regional model for the Sardinia region, commissioned by the local government to plan water resources management. SIDRO is user friendly and SWAT input/output data is interfaced to the final user with interactive maps and tables.

Keywords

SWAT, Web-GIS, SIDRO, web-application, database

Sensitivity of water quality of three contrasted north-eastern French watersheds to climate change (2006-2100) using SWAT model

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Abstract

The SWAT model has been chosen to assess climate change impacts on water quality of three subbassins of north-eastern France: located on headwaters of three major rivers of France (Loire, Seine and Rhône rivers respectively). These watersheds have a size less than $3000km^2$ and present different hydrogeological and geological characteristics. Land-use as well as their agricultural practices being also diversified, the three watersheds studied constitute a relevant experimentation area.

The goal of this study is to assess local vulnerability of surface water quality (sediments, nutrients, dissolved oxygen loads) to climate change (2006-2100) following the Representative Concentration Pathways (RCP) 8.5. To this purpose, a database (soil, land-use and daily climate data) has been built. Climate change is provided at 12 km-resolution by a dynamical downscaling of a General Circulation Model (GCM) using a Regional Climate Model (RCM). Changes in exports from watersheds (total suspended sediments, $N-NO_3^-$) and evolution of biotic conditions in the mainstream (dissolved oxygen and chlorophyll a levels) are analyzed. Further analysis will provide results for many other concerns: agronomy (study of the evolution of available soil water quantity) or watershed management (sensitivity studies of land-cover and fertilization change impacts) and will allow concrete decision-making at local scale.

Keywords

Climate change, surface water quality, vulnerability, headwaters, France, SWAT model.

After the flood is before the flood: impacts of climate change on flood hazard and risk in Germany

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Abstract

Our study presents and discusses possible trends in flood generation under climate change conditions in Germany. The study makes use of the newest set of climate projections regionalized for the main river basins in Germany. A hydrological model was applied to transform these scenarios into river runoff for more than 5000 river reaches. Previously, the model has been calibrated and validated for the main gauges within the German river basins. Extreme Value Distributions have been fitted to the hydrographs of the river reaches to derive the basic flood statistics. The results for each river reach have been linked to related damage functions as provided by the German Insurance Association considering damages on buildings and small enterprises. The result is that under the specific scenario conditions a significant increase in flood related losses can be expected in Germany. This outcome confirms previous studies using different sets of climate scenarios and increases thereby the robustness of the results and general assumptions.

Keywords

Climate change impacts; Flood hazard; Flood risk

Future river projections for a steep, rapid responding, catchment on the west coast of the UK

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Abstract

Future climate projections suggest that river flow will change. This will have a significant impact on the downstream and estuarine environment. For example, sediment fluxes, carbon sequestration, and eutrophication patterns may change. In turn, we may see shifts in species distribution and species introductions. Climate-driven changes, therefore, require an integrated catchment-to-coast approach to investigation and management.

In general, recent research have shown that a combination of increased precipitation and river flow rates in winters and decreased precipitation and river flow rates in summers is expected in estuaries within the west coasts of the UK. A small catchment in mid Wales (Dyfi estuary) was simulated to study the changes in future river flow based on the rainfall distribution assuming three different scenarios: low emission scenario, medium emission scenario, and high emission scenario. The Dyfi system has been found as a good test bed for model development and verification in previous studies. Further, previous studies of simulated Dyfi river flow could not match observations, and therefore future projected river flow changes could not be resolved. We hypothesised the catchment model could not accurately resolve the Dyfi.

For catchment modelling, SWAT has been used. SWAT is an open source model widely applied to catchment studies. After calibration and validation of the model, SWAT was forced with various meteorological data assuming different scenarios including fifty years of observed data, fifty years of the near-future, and fifty years of the far-future. The impact of the climate change on the river flow was investigated.

Keywords

Climate Change, Catchment, Emission Scenarios, SWAT Model, River Flow.

Evaluation and focusing of Soil and Water Conservation measures using SWAT model in Krishnagiri Reservoir Catchment area, South India

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Abstract

The present study evaluated the effectiveness of Soil and Water Conservation (SWC) measures implemented in the catchment area of Krishnagiri Reservoir that has lost 52 % of its capacity in a span of 55 years supporting 3462 ha of irrigated agriculture in the drought prone area of eastern Tamil Nadu, South India. SWAT model was applied to the catchment area calibrated and validated using 13 years stream flow and sediment yield data from 1998 to 2012. Nash-Sutcliffe model fit for monthly stream flow was 0.89 for calibration and 0.83 for validation period. Similarly 0.73 for calibration and 0.76 for validation was obtained for sediment simulation indicating satisfactory model application. Sediment generation in the catchment through simulation in SWAT model was compared with area covered under SWC by the present methods. SWAT indicated an area of   34.76 km^2 as severe eroding zones of which 32.96 km^2 was covered by the present SWC measures leaving an area of 8.8 km^2 to be covered. Further 20.2 km^2 area of the present program was not classified as severe erosion class by the SWAT model. Focussing the efforts in the severe erosion area identified by the model can improve reduction in sediment yield by 36 %. SWAT also simulated other suitable SWC measures on sediment yield from the catchment. Among them mulching followed by bio-fencing and minimum tillage will greatly improve efficiency of the sediment reduction when implemented. The scrub land in the catchment area contributes higher sediment yield than agricultural lands. Scrub lands constitute 12.35% area of the catchment, but generate 48.5 % of total sediment which is more than 14.5 % of agricultural lands. Simulation results shows that covering the scrub land with plant residue (mulching) can significantly reduce sediment yield upto 1.72 t/y from 8.61 t/y. Therefore the present study suggests Bio-fencing which is a cost effective measure in scrub lands can reduce 1.72 t/y and more attention is required here.

Keywords

Soil and Water conservation, sediment yield, SWAT

SWAT Hourly Calibration using SWAT-CUP for a Large Watershed in Southeast Brazil and Flooding Applications

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Abstract

Application of hydrological models to watersheds at a sub-daily time step is very important for better understanding of flow and water quality dynamics. The urgency of such applications and developments has increased in recent years due to increased urbanization, and higher frequency of extreme hydro-meteorological events. Climate change impact and accelerated landuse change due to population growth can exasperate the situation in the coming years. The Soil and Water Assessment Tool (SWAT) is internationally accepted as a robust interdisciplinary versatile watershed model, having being applied in many studies around the world. There are few applications utilizing the sub-daily capabilities of SWAT. A new component to allow hourly calibration has been incorporated in the SWAT-CUP software package (SWAT's calibrator). This study presents the application results of an hourly SWAT model using SWAT-CUP (SUFI-2 algorithm) for calibration. The case study is the ~12,600 km^{2}Piracicaba Watershed, in Southeast Brazil. The watershed is rural and mainly covered with sugar cane and pasture, but it has considerable areas with forest cover, and significant urban areas (in which about 3.5 million people live). It is also a very relevant watershed for such application because it has high hydrological variability. The region is prone to severe flooding and droughts. The Piracicaba SWAT Model was first calibrated with daily climate datasets for yearly average values, monthly and daily time steps, and then with more limited hourly rainfall datasets for daily and hourly time steps. Calibration of this model resulted in satisfactory and reasonable results. This study brings a parameter uncertainty discussion, as well as an application of the SWAT hourly Piracicaba model for flood forecasting. We used an ensemble of weather forecasted data from the ETA model of CPTEC/INPE (Center for Weather Forecasting and Climate Research/ Brazilian National Institute of Space Research). This developed method foresees future applications which can help the real time operational decision making for disaster risk reduction of hydrological extremes at strategic river basins in Brazil.

Keywords

Extreme Events; SWAT-CUP hourly module; Piracicaba Watershed.

Study of the hydrological functioning of the Béjà river watershed, in the northwest of Tunisia, using the SWAT model

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Abstract

The water pollution from agriculture and human activities has become a hot topic. Its evaluation by the quality and quantity has been well demonstrated by the SWAT model. The application of this model requires prior study of the hydrological catchment regarded and the calibration of a large number of intrinsic factors particular to the study area. This model was mainly tested on several watersheds in Nordic countries such as Canada and France. Its adaptation to the Mediterranean context is seldom realized. For the case of Tunisia, the lack of long series of continuous measurement data and hydrodynamic soil handicap further the application of the SWAT model.

This work permitted to assess the performance of hydrologic functions of the SWAT model and to adapt it to the context of a watershed characterized by subhumid heavy soils in northern Tunisia, and to better understand the hydrological functioning of this basin. It was shown the need to initialize the model at least one month in advance to a desired time period. In addition, a calibration approach of the various parameters has been proposed taking into account particularly the distribution of rainfall during the period. In the calibration approach, the sensitivity analysis model showed the importance of some hydrodynamic parameters such as hydraulic conductivity at saturation, bulk density and cation exchange capacity, and the interactions of various phenomena related to the hydrological balance of the water at the final outlet, namely runoff, percolation and evapotranspiration.

Keywords

Ks: Hydraulic conductivity at saturation of the soil, CH-N: Manning roughness coefficient, Da: bulk density, CEC: cation exchange capacity, SWAT: Soil Water Assessment Tool

An experiment on the temporal transposability of the SWAT model on a large contrasted watershed.

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Abstract

Most of the modeling works about the impact of climate change on the hydrologic regime of river focus on overland flows or, less frequently, on aquifer recharge, soil water content, reservoir storage or snow cover. This study considers all main components of the water cycle and tests the ability of the SWAT model to describe them for the Garonne catchment scale (50,000 km[2]).

Applying the differential split sampling test, proposed by Klemeš (1986), SWAT temporal transposability is evaluated in face of land used changes and climatic statistics variation over a 50-year period (1960-2010). To achieve this, different calibrations have been realized, using SWAT-CUP and a data set from 21 gauging stations along the fluvial continuum. Performance of the discharge simulation is thereafter evaluated at a monthly time step, over this same period (1960-2010) along with the consistency of the simulation of various hydrological cycle component.

Results highlight trends toward the water repartition at an annual scale within the watershed over the last decades. A global decrese of the Garonne river flow is observed, mainly due to the reduction of precipitation and a positive trend of the simulated evapotranspiration. A good ability of the SWAT model to assess variations of hydrological cycle components over past 50 years has been conclued in this work, enable its use for future variation of those same components over the next 50 years.

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Keywords

SWAT, Hydrological cycle, Differential split sampling, Climate Change, robustness, Garonne River

Recovery of salt contaminated soils using halophytic plants for sustainable agriculture and water resources

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Abstract

Nearly 20% of irrigated agriculture suffers from soil salinization, which causes reduced crop yield, especially in arid and semi-arid regions. About 1% of the world's flora are known as halophytes, or plants that are capable of completing their lifecycle in higher saline soil or water environments. Halophytes are not commonly cultivated, but may be useful for human consumption, biofuel, or animal consumption. To assess the potential of halophytes to be cultivated in salt-affected agricultural sites, the Agricultural Policy/Environmental Extender (APEX) model was augmented to include a salinity module that is capable of tracking salinity through the soil-plant-water interface. The halophytes Atriplex nitens, Climacoptera lanata, and Salicornia europeae were parameterized in the APEX model's crop database. Field data collected from two sites in Uzbekistan in 2013 were used for testing the model. After running 500 simulations with random combinations of sensitive parameters, best fit results between observed and modeled values for crop biomass, crop height, and soil EC had deviations of as much as 42.5 tonnes/ha biomass, 200 cm of crop height and 23 mS/cm of EC, respectively. Suggestions for model improvements include enabling the modeling of individual salt ions because plants may experience toxic effects of different ions.

Keywords

APEX, salt, halophyte, soil contamination

Integrated Decision Support System: A framework that facilitates the integration of biophysical and economic models.

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Abstract

Integration of models is often used to deal with complex problems that exist across multiple spatio-temporal scales or fields of research. Water scarcity is such a problem many sub-Saharan countries must deal with to secure foods and drinking water. A suite of biophysical and socio-economic models can be useful tools to address benefits of small scale irrigation technologies on water availability and food security, if these tools are applied in an integrated manner. The Integrated Decision Support System (IDSS) is the framework for integrating SWAT, APEX and FARMSIM models. The Soil and Water Assessment Tool (SWAT) is a biophysical simulation model that quantifies the impacts of land management practices in large complex watersheds or river basins. The Agricultural Policy Environmental Extender (APEX) is also a biophysical simulation model that is used to evaluate detailed crop management technologies that affect agricultural production and environmental sustainability at the scales of individual fields, whole farms, or small watersheds. The Farm Income Simulator (FARMSIM) is a farm level model for economic analysis of farming practices. These three models are integrated in IDSS, providing a modeling solution that links agricultural production, economics, and environmental consequences of irrigation technologies for decision makers. The Framework for model integration in IDSS will be presented: first, the model integration strategy in IDSS which takes advantage of multiple spatio-temporal scales and strengths of the models; second, case studies will be presented for agricultural watersheds in the St. Joseph River County, U.S.A. and the Amhara Region, Ethiopia. The case studies demonstrate the usefulness of the IDSS approach to assess agricultural practices that improve agricultural productivity, management of soil and water resources, and improved family nutrition and livelihoods of the stakeholders.

Keywords

APEX, SWAT, FARMSIM, Model, Biophysical, Economics

Biogeochemical Modeling with APEX

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Abstract

Agriculture is an essential human activity practiced for millennia to satisfy food, feed, fiber, and energy needs. These agricultural practices have had profound effects on ecosystem processes including alterations of the hydrological cycle in agricultural watersheds, gains and losses of soil organic carbon and nitrogen, and increased emissions of nitrous oxide. In order to mitigate / adapt to climate change and ensure the long-term productivity of agroecosystems, it is imperative to design—via experiments and / or modeling—agricultural practices that help maintain or sequester atmospheric carbon and reduce nitrous oxide emissions. During the past decade, we implemented and tested algorithms in the EPIC (Environmental Policy Integrated Climate) model to simulate coupled carbon-nitrogen cycling and nitrous oxide emissions via microbial denitrification. Here we describe the implementation and initial testing of these algorithms in the APEX (Agricultural Policy / Environmental Extender) model. We expect these new features in APEX will allow for a more holistic understanding of biogeochemical cycles at farm and watershed scales by accounting for both the vertical and lateral fluxes of carbon and nitrogen arising as a result of farm management and environmental conditions.

Keywords

Carbon cycle, nitrogen cycle, nitrous oxide, climate change mitigation, sustainable agriculture

Impact of climate change and agroecosystem model configuration on simulated uncertainty of cotton production and water quality

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Abstract

Climate change is a major threat to agriculture. Agroecosystem modeling framework is often used to project the likely climate change impacts on crop production, soil organic carbon change, and water quality variation. However, the choices of emission scenarios, climate models, downscaling techniques, and agroecosystem modeling selections all contribute to predictive uncertainty. The goal of this study is to assess the impact of future climate scenarios, agroecosystem model configuration and parameters on projected changes in cotton production and water quality variation. A range of model configuration choices, corresponding parameter sets, and climate change scenarios will be evaluated and the predictions' confidence limits will be reported.

Modelling the effect of riparian vegetation restoration on sediment transport in a human-impacted Brazilian catchment

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Abstract

Soil erosion threatens both soil and water resources and has increases globally due to changes in land use, mainly the substitution of natural vegetation by agricultural crops and pasture, or the intensification of existing agriculture. Brazil is privileged by a large proportion of natural vegetation and abundant freshwater. Recently, a new Brazilian Forest Act (BFA) has been approved that offers landowners that had committed illegal riparian deforestation in the past amnesty from reforestation, and further reductions of riparian protected areas are currently discussed. Here. we used the Soil and Water Assessment Tool (SWAT) to simulate river discharge and sediment exports in a typical human-impacted Brazilian catchment, the Rio das Mortes Basin in the Federal State of Minas Gerais. Our model simulated different scenarios of riparian zone reforestation and their benefits in reducing sediment exports. By restoring the riparian vegetation according to the BFA ignoring amnesties to land owners (i.e. 44.8% of the 200 km^2 legal riparian corridor of the river, with a corridor width of 30-50 m), the current annual sediment yield of the catchment of 0.819 t ha^{-1} was reduced in 34%. Further, simulated reforestation twice the size demanded by the BFA (60-100 m corridor width) resulted by 34.8% reduction of the current sediment yield. However, reforestation of 5 m homogeneous riparian corridor only, as currently discussed in the Federal Brazilian State of São Paulo, reduced sediment exports by 28%, not considering expected additional erosion due to deforestation outside the simulated reforested 5 m corridor. Our study is the first basin-wide assessment of the role of riparian vegetation in preventing soil erosion in Brazil. Its results support intensive reforestation efforts of the riparian zone and point to substantial negative effects of further reductions of the protected riparian corridor width and amnesties from reforestation to land owners.

Impact of best management practices to improve water quality from mountainous catchment: Haean catchment in South Korea

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Abstract

Intensive agricultural practices to secure crop yields have negative effects on the environment due to the generation of sediment and nutrients from agricultural fields. The monsoon climate and current agricultural practices in the foothills of the Haean catchment in South Korea aggravates water quality by transporting sediment and nutrients to downstream water bodies. Aim of this study is the permanent reduction of sediment and nitrate from this catchment through an efficient application of best management practices (BMPs). Under consideration of evidence from previous plot level studies, we applied two BMPs, i.e., split fertilizer application (SF) and winter cover crops (CC) and both in combination (SFCC) to major dryland crops (cabbage, potato, radish and soybean), in order to investigate their effectiveness at the catchment scale by using the Soil and Water Assessment Tool (SWAT). We found that the SF scenario reduced nitrate generation while it did not show any change in sediment and crop yield from the baseline (BL) scenario. The application of the CC scenario reduces both sediment and nitrate while increases crop yields. The combination of the scenarios (SFCC) showed higher positive effects than their single application on reducing sediment and nitrate and increasing crop yield. We determined the variation of the effectiveness of BMPs and could demonstrate that specific sites and crop types such as soybean were less supportive to reduce sediment and nitrate. Those sites and crops could be considered for additional BMP measures to increase the reduction level of target pollutants. Recommendations for BMP applications should also include minor crops and other land use types within the catchment in order to efficiently retain agricultural water pollution and to secure high crop yields in this region.

Keywords

BMP, Split fertilizer application, winter cover crop, sediment, nitrate, crop yield

SWAT model as a part of the integrated monitoring and modeling system for the Goczalkowice Reservoir basin

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Abstract

Sustainable management of water resources cannot be achieved without good information on the state of the environment and emerging trends. According to both: local (regional, national) and international regulations (e.g. EU Water Framework Directive) the appropriate management should include the assessment of changes in natural conditions and those resulting from human impact. Therefore, there is a strong need to integrate all available sources of information on environment and results of monitoring in one user-friendly tool which can significantly shorten the time required for the identification of processes affecting the water status. Such tool, called CRIS (Complex River basin Information System) is being developed in the CRIS project and demonstrated in the Mala Wisla river basin (southern Poland) with area of approx. 530 km[2] and a large dammed reservoir at the outlet. The information system integrates (1) spatial information on the analyzed area in a form of GIS layers (land use, soil, geology, surface elevation, etc.), (2) all available monitoring data including the real-time data acquisition, (3) a modeling module (set of modeling tools) simulating water balance and the transport of nutrients and sediments and (4) a user graphic interface in a form of data visualization via the CRIS project website. SWAT model (Soil and Water Assessment Tool) is the central part of the modeling module. SWAT inputs are based on the real-time flow gauges data and outputs from the WRF (Weather Research & Forecasting) model regarding all meteorological parameters. It is worth mentioning that the WRF model applied in the CRIS information system

was also configured to be corrected basing on the weather radar observations. The SWAT model provides not only the daily data on water balance elements (channel flow, runoff, percolation, evapotranspiration) and water quality for the online information system but also feeds other models with input data. SWAT outputs regarding water inflows to the dammed reservoir and loads of nutrients and sediments are to be used as an input to the GEMSS model (Generalized Environmental Modeling System for Surface waters) for the simulation of 3D hydrodynamics and water quality in the Goczalkowice Reservoir. Additionally, SWAT output data regarding recharge entering aquifers together with loads of nitrogen are designed to be used as an input to the MODFLOW (Modular Three-Dimensional Groundwater Flow) model simulating the groundwater flow in the analyzed river basin.

Keywords

water management, monitoring, modeling, SWAT, integration, river basin

Assessment of surface water - groundwater exchanges and shallow aquifer denitrification in alluvial floodplain at catchment scale using SWAT model

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Abstract

As alluvial plains support intensive agricultural activities, they often suffer from groundwater nitrate pollution. Denitrification is recognised as an important process in nitrate pollution control in the riparian zone. In shallow aquifer zones influenced by recharged surface water, denitrification efficiently attenuates nitrate in groundwater as well, and the exchange between surface water and groundwater (SW-GW) has a significant impact on the occurrence of denitrification. Denitrification is simulated in numerous models, however most models do not take into account the two directions SW-GW exchanges and associated denitrification processes. Denitrification is occurring in shallow aquifers under the influence of recharge surface water according with the supply of organic carbon and bacteria. New modules that represent the occurrence of SW-GW exchange and denitrification in the shallow aquifer of alluvial floodplains were added to the SWAT model and the modified model was called SWAT-LUD. The application of SWAT-LUD in the middle section of the Garonne floodplain proved that SWAT-LUD could simulate the SW-GW exchanges including flood events and aquifer nitrate concentration in the riparian zone satisfactorily. In this study, a numerical tool called Creat-LU was developed to separate classic subbasin and subbasin-LU, the parameters of LUs in the subbasin-LUs were generated with this tool also. SWAT-LUD was applied at the Garonne catchment scale. The influence of SW-GW exchanges on river water discharge and groundwater and the influence of shallow aquifer denitrification on river water nitrate flux were quantified.

Keywords

SWAT-LUD model; water exchange; denitrification; floodplain aquifer; Garonne River

Permafrost thaw affects mass soil erosion with potential for eutrophication of the Arctic Ocean under continued climate change

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Abstract

The polar regions of the planet are the most sensitive regions to continued climate change with expected temperature increases greater at higher latitudes. Temperature changes at the poles over the past century have already resulted in observable changes in environmental conditions and ecological processes in polar ecosystems. Of particular interest is the thawing of permafrost, which in addition to a definitive result of climate change, may have large scale impacts on both terrestrial and marine arctic ecosystems due to soil loss associated with permafrost thaw. Slope soil erosion associated with climate change are characterized by high frequency, low intensity processes referred to as solifluction, and low frequency (or uncommon), high intensity events referred to as active layer detachments. Both processes are increasing transport of soil and parent material and organic matter to the Arctic Ocean. To assess the contribution and limits of SWAT to this issue, we developed and calibrated simulations for the West River located at the Cape Bounty Arctic Observatory, Melville Island, Nunavut (74°50'N, 109°30'W). Landcover, dominated by tundra vegetation, was determined from classified IKONOS imagery. Soils were classified uniformly as Lithosols with depth derived from derivation of a topographic saturation index scaled to a maximum value of 50 cm based on lidar-derived digital elevation data for the watershed. Twenty years of simulation were run based on daily input meteorology from the National Centers for Environmental Prediction (NCEP) reanalysis dataset. Surprisingly, calibration of stream discharge for the melt season hydrology of the river was fairly successful (r^2=0.74). Parameter values changed in this calibration included the baseflow alpha (0.3), deep aquifer percolation fraction (0.01), groundwater delay time (1), and hydraulic conductivity in channel alluvium (480). We interpret the importance of these parameters to successful calibration of the hydrologic discharge to represent a fairly shallow soil water system underlain with an impermeable layer coupled with highly transmissive stream bed material. Comparison of inorganic nitrogen sources observed for the river corresponded to range of values simulated ranging from 0.01 – 0.05 mg/L during summer months. Sediment data were collected from the watershed show a maximum suspended sediment load of 1750 mg/L with a watershed specific yield of 315 Mg/km². Simulated values from SWAT were approximately half of this value. To account for missing sediment, we exported soil moisture values by reach to use as inputs into the

Stability INdex MAPping (SINMAP) to assess soil stability. This showed that areas with high soil saturation on relatively steep topographic positions in the watershed were more likely to produce minor landslides consistent with active layer detachment processes. Simple mass analysis of these sediments still did not equal the amount of sediment yield indicating that soilfluction also plays a role for producing sediments under low flow conditions. Current trends indicate changes in precipitation and humidity affecting timing and amount of discharge in this particular watershed. Inclusion of a permafrost layer, coupled with mass wasting functions appropriate for tundra soils into SWAT are necessary for improved and integrated modeling of this landscape to assess future changes in sediment yields from these watersheds into the Arctic Ocean.

Keywords

Arctic Ocean, permafrost, soilfluction, saturated soil

Modeling the Impacts of Climate Change on Groundwater Recharge in the Gharehsoo Watershed, Iran, from an Ensemble of Global Climate Model Projections

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Abstract

Groundwater is the source of nearly 35% of global human water withdrawals, and even of about 42% of the total global irrigation water withdrawals. It is a more reliable and safer water source than surface water, because its use is less impacted by seasonal or inter-annual flow variations (e.g. drought periods) and it is much better protected from anthropogenic pollution.

Due to the increased temporal variability of surface water flows in the wake of climate change, there has been and will be, more so, in the near future, a higher demand for groundwater. In fact, this has already led in some semi-arid and arid regions with intensive irrigation (Iran) to groundwater abstraction rates, exceeding groundwater recharge, i.e. to strong groundwater depletion. To support a sustainable groundwater management, it is necessary to assess the renewable groundwater resources, i.e. the long-term average annual groundwater recharge. Modeling the impact of climate change on the future renewable groundwater resources under various scenarios can help to identify regions with significantly-changing groundwater resources and, thus, inform on the planning of possible measures for climate change adaptation.

In this study the SWAT- (Soil Water Assessment Tool) semi-distributed hydrological watershed model has been applied to estimate the shallow groundwater recharge at the watershed scale. The study area is the Gharehsoo basin, located in northwest of Iran and includes most parts of Ardabil province and a small area of East Azerbaidjan province. This watershed is one of the most important areas from which considerable water for human- and agriculture uses is generated. The dominant land-use types of the watershed are mixed-range- and agricultural lands.

The input data for the SWAT- model have been prepared using the digital land-use and soil maps with monthly rainfall data measured at the main rain gauge station as well as other meteorological variables such as wind speed, relative humidity, solar radiation, and temperature collected within the watershed. The SWAT- model has been calibrated based on 34 years of monthly streamflow recorded between 1974 and 2000 and then validated on the remainder of the streamflow time series from 2001 to 2013.

In the subsequent step, downscaled climate predictions from an ensemble of climate models (GCM) have been imported into the SWAT-model to estimate the past (for reference) and future groundwater recharge. The results indicate that future groundwater recharge all over the watershed will be decreased due to the impact of climate change in the region, namely, higher temperatures and less precipitation.

Keywords

Groundwater recharge, climate change, downscaling, SWAT-model, Gharehsoo basin, Iran

A Methodology to Assess the Role of the River Discharges to the Gulf of Cadiz on the Nutrient Supply to the Alboran Sea

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Abstract

In the frame of the MEGAN Project, an integrating approach is proposed in order to understand the marine ecosystem connections between the Gulf of Cadiz and the Alboran Sea, including those processes controlling the nutrient inputs and the corresponding biological response. Among the main processes, the river discharges to the Gulf of Cadiz are expected to play an important role in contributing to the nutrient supply to this system, as it may be inferred from turbidity images acquired by several satellites.

To asses the influence of these discharges a methodology based on the catchment model SWAT have been developed for the Guadalquivir river basin. After the calibration and validation of the model, some numerical experiments are performed under characteristics meteorological patterns of the region, which have been simulated with the MM5 atmospheric model. The results obtained have allowed a first evaluation of the contribution of the river discharges to the nutrient input to the Gulf of Cadiz. Further extension of the methodology to the other relevant river basin discharging to the Gulf of Cadiz and the Alboran Sea, along with the evaluation of the other involved processes, will allow to assess the relative importance of the river discharges to the Gulf of Cadiz in the nutrient supply to the Alboran Sea through the Strait of Gibraltar.

Keywords

Catchment, SWAT Model, River Flow, Turbidity, Strait of Gibraltar, Guadalquivir, Alboran Sea, Satellite.

Assessment on Hydrologic Response by Climate Change in the Chao Phraya River basin, Thailand

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Abstract

Chao Phraya River in Thailand, which is the country's major river, serves mostly as a source of irrigation water and transportation route for Central Thailand. The river has been greatly affected by climate change and the occurrence of extreme flood events, hindering its economic development. The objective of this study was to assess hydrological responses of the Chao Phraya River basin under several climate sensitivity scenarios and greenhouse gas (GHG) emission scenarios (B1, A1B, and A2 in CSIRO Mark 3.5) from Global Circulation Model. The Soil and Water Assessment Tool (SWAT) model was applied to simulate streamflow using meteorological data and observed data over a 9-year period from 2003 to 2011. The SWAT was able to produce an acceptable simulation performance for calibration and validation, yielding NSE values greater than 0.5. Precipitation scenarios yielded streamflow variations that correspond to the change of rainfall intensity and amount of rainfall while scenarios with increased air temperatures expect water shortage in the future. Scenarios with increased CO_2 concentration incorporated plant responses which led to a dramatic increase in streamflow. Combining these climate scenarios with maximum increase of precipitation and air temperature yielded annual average changes of 18.4%, 52.6%, and -6.2%. Increased percentages in streamflow variations were observed 6.8%, 41.9%, and 38.4% from baseline (2003-2011) in the GHG emission scenarios. This study also provided an approach on peak flow management to control the nonpoint source during wet season which could reach to 22.7%, 72.3%, and 70.1% after May. We hope that future climate scenarios in this study could provide predictive information for the river basin.

Climate and land-use change impacts in the São Francisco Basin, Brazil

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Abstract

Climate and land-use changes impact the flow regime of river basins. The eco-hydrological model SWIM (developed based on SWAT-1993 and MATSALU) was calibrated and validated for the São Francisco river basin (ca. 630,000 km3; Brazil) and used to simulate land-use and climate change scenarios.

The climate scenarios used show increasing temperatures but depending on the climate model increasing or decreasing annual precipitation ('wet' and 'dry' in the following). The simulation of the natural state, i.e. without management effects of reservoirs, water transfers etc., for the wet scenario shows an increase of the mean annual discharge at gauge Traipu. For the dry scenario a decrease of the mean annual discharge is simulated. The simulation of the managed system, including hydropower generation, water withdrawals etc., gives an annual hydropower generation of 50,550 GWh/a for the wet scenario. For the dry scenario the annual generation is 39,933 GWh/a. Also proposed new reservoirs, mainly used for hydropower generation, and new irrigation schemes were included in the scenario analysis. New reservoirs included are Riacho Seco and Pedra Branco with generation capacities of 240 MW 320 MW, repectively. Making use of data from Companhia de Desenvolvimento dos Vales do São Francisco e Parnaíba (CODEVASF) regions with potential for irrigated and rain-fed agricultural use were derived. In scenario "extension" all planned and potential irrigation projects of CODEVASF are implemented, while in a second scenario ("reference") only projects already started will are realized. The water demand in the extension scenario increases to a mean value of 370 m3/s in the year 2030, while in the reference scenario it is 155 m3/s. For both scenarios a high safety of water supply is simulated in the wet scenario. In the dry scenario even for the reference scenario high deficits are simulated. The impacts of irrigation water requirement on hydropower generation are rather low. A strict observation of minimum discharges is assumed in the simulations (only water above minimum discharges can be withdrawn).

Keywords

SWIM, rio São Francisco, water management, climate change, land use

A large-scale and fine resolution SWAT model for an assessment of isolated climate change impact on unaltered flow regimes in Central Eastern Europe

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Abstract

The Vistula and Odra basins (VOB) whose total area in Poland, Germany, Czech Republic, Slovakia, Ukraine and Belarus amounts to 313,000 km[2] belong to the five largest river basins in the European Union. One of the central objectives of the CHASE-PL (Climate Change Impact Assessment for Selected Sectors in Poland) project is to develop an ensemble of climate change projections and their associated impacts on water resources in this area using the SWAT model. The ensemble will consist of 10+ EUROCORDEX RCMs bias-corrected using the quantile mapping method. The developed model setup covering both river basins consists of 2633 subbasins and 17685 HRUs and uses 5 km gridded precipitation and temperature input data interpolated from more than 700 stations. Since water management e.g. reservoirs, water withdrawals and point source discharges can mask pure climate change effects, the latter are isolated from others by focusing the model calibration process on a large set (~80) of "benchmark" meso-scale sub-catchments (500-3000 km[2]) with relatively unaltered flow regimes. In such a way the calibrated large-scale model will enable fair spatial comparison of projected climate change impacts on different flow regime types of the VOB. An approach involving the Indicators of Hydrologic Alteration (IHA), Principal Component Analysis and cluster analysis is employed in order to classify flow regimes of the "benchmark" catchments. Model calibration and validation against daily discharge data is done separately for different flow regime clusters. Parameter transfer to ungauged sub-catchments is done using a selected parameter regionalization approach. This study shows the developed protocol for large-scale and fine resolution hydrological modelling as well as some preliminary results of its implementation in the SWAT models of the VOB.

Keywords

Poland; climate change; flow regime; spatial calibration

Large scale water quality modeling in Lithuania: parameterization, calibration and validation using PAIC-SWAT tool

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Abstract

Large scale water quality modelling at country scale was developed as a decision supporting tool to help and reinforce the Water Framework Directive of the European Union in Lithuania to enhance ecological status for all water bodies. For this meaning, a SWAT model was set up and calibrated to support the Environmental Protection Agency (AAA) to provide the river basin management plans for entire watersheds in Lithuania. The modeling system was developed by Soil and Water Assessment Tool (SWAT2012) rev627 implemented and imbedded in a Python workflow by the Center of Processes Analysis and Research PAIC to predict surface water flow and nutrient concentration in entire Lithuania using available datasets. A regionalisation strategy has been set up by identifying 13 hydrogeological regions according to the hydrological characteristic and pollution generation conditions. In each hydrological region, a representative catchment was selected and calibrated using combination of manual and automated calibration approaches.

After final parameterization and fulfilling of calibrating and validating evaluation criteria, the parameters sets have been extrapolated for other basins within the same hydrogeological region. Multi variable cal/val strategy was implemented while the applied variables are river flow and in-stream NO3, Total Nitrogen, PO4 and Total Phosphorus concentrations. The criteria used for calibration, validation and extrapolation are: Nash-Sutcliffe Efficiency (NSE) for flow and R-squared for water quality variables and PBIAS for all variables. In hydrological calibration, NSE should be achieved to 0.5 and for validation and extrapolation respectively to 0.4 and 0.3. Besides for flow variable, PBIAS error has to be less than 20% for calibration, and for validation less than 25% and extrapolation less than 30%In water quality calibration, R-squared values comparing observed and simulated nitrogen variables should be higher than 0.5 for calibration, 0.4 for validation and 0.3 for extrapolation. Besides PBIAS error should be less than 40% for calibration and less than 70% for validation and extrapolation for all mentioned water quality variables. To calibrate the hydrology part, 62 stations with daily discharge for 1997-2012 were provided. The basins with data-rich stations for calibration and validation were recognized and

available data were divided to three parts to use first and last one-third for calibration and one-third in the middle for validation. To calibrate water quality part, more than 500 stations for 1997-2012 were provided and 135 data-rich stations were assessed. Similar to hydrology, available data was divided to three parts to use first and last parts for calibration and middle part for validation.

Finally, by implementing this regionalisation strategy, the model could successfully fulfill most of the criteria. In more than 90% of hydrological stations, the model satisfactorily predicts the selected variables whilst this prediction reliability were achieved for more than 95% of entire water quality stations

Keywords

Water Quality Modelling, Regionalisation, Parameterization, Nitrogen and Phosphorus Prediction, Calibration, PAIC-SWAT.

A global SWAT model

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Abstract

In many parts of the world freshwater availability and quality are declining because of urban, industrial, and agricultural driving forces. A consistent quantification of water availability and quality not only in individual river basins but also at the global scale has been identified as a major research need in hydrology. Such a consistent quantification is required to support environmental managers in developing methods for a sustainable use of water. In this study, a grid-based hydrological model of the world has been developed at a spatial resolution of 5' and 30" (approximately 10 and 1 km at the equator) using the Soil and Water Assessment Tool (SWAT). SWAT computes surface runoff, lateral flow, groundwater recharge, and evapotranspiration for each grid cell. The model is based on global land use, soil type, and weather databases. Topography and flow directions are derived from data provided by the USGS HydroSHEDS (Hydrological data and maps based on Shuttle Elevation Derivatives at multiple Scales) program. Preliminary spatial model results such as surface runoff, subsurface flow, and evapotranspiration are presented. The model has not been calibrated yet, so the output was analyzed qualitatively instead of quantitatively. In addition, issues of data availability and technical limitations are discussed. In the future, the model will be calibrated against observed streamflow to assess the reliability of the output.

Keywords

Water resources; water cycle; USGS HydroSHEDS

Advancements in SWAT Urban Simulation Capabilities to Evaluate Green Stormwater Infrastructure in an Urban Catchment

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Abstract

Many areas are encouraging the use of 'green' infrastructure and low impact development (LID) such as rain gardens, rainwater harvesting cisterns, green roofs and porous pavement as methods to control stormwater runoff. A variety of approaches are being used to evaluate the benefits of these controls from simple spreadsheet models to complex models. The results of these evaluations may have a significant impact on the feasibility of retrofit projects in urban areas where existing infrastructure may be undersized, creating problems with runoff. This paper utilizes advancements in the urban simulation capabilities of SWAT to simulate a small urban catchment with known localized flooding problems and evaluates the effectiveness of different LID techniques to alleviate those problems. The SWAT modeling methodologies for LID will be compared to similar scenarios performed using PC-SWMM.

Keywords

Green infrastructure, lid, stormwater, runoff, swat, urbanization

Effectiveness of decentralized green infrastructure for urban stormwater management

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Abstract

Implementation of green infrastructure (GI) (or often called low impact development) can be a useful measure to mitigate negative effects of urbanization on hydrology and water quality by enabling on-site stormwater management. Assessing the performance of green infrastructure is essential in stormwater management and for water infrastructure planning. This study investigated the effectiveness of decentralized green infrastructure including green roofs, rain gardens, cisterns, and porous pavements on water balances in a highly urbanized watershed (149.5 ha) in Austin, TX using the Soil and Water Assessment Tool (SWAT). For the GI assessment, sub-modules were developed in SWAT2012, and the model was calibrated and validated for sub-hourly stormwater discharge hydrographs measured in the watershed. GI parameters and geometric properties influential to the model performance were identified through sensitivity analysis. Twenty-six GI implementation scenarios were evaluated using the calibrated model. The sensitivity and scenario analysis demonstrated varying performance of the selected GI with respect to the characteristics of storm events and GI configuration, suggesting a need for a study on critical storm events and efficient GI placement plans to maximize their utility. The results showed that the GI practices were more effective in reducing stormwater volume than peaks and the effectiveness was proportional to GI application areas. The implementation of LID practices also increased the amount of water infiltrated into soil layers and subsequently increased soil water contents, which then lead to increases in aquifer recharge and evapotranspiration. This study demonstrated utilities of the newly developed green infrastructure modules in SWAT as a tool for urban stormwater simulation and for urban watershed planning.

Keywords

SWAT, green infrastructure, low impact development, green roof, rain garden, cistern, porous pavement

Evaluation of surface runoff conditions by high resolution terrestrial laser scanner in an intensive apple orchard

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Abstract

High resolution terrain data and plant coverage are essential input SWAT parameters. Extreme water management features of soils can be evolved due to the heterogenic micro relief and extreme weather conditions – which caused by climate change – in the Carpathian basin, in Hungarian Great Plain. These factors can saturate soil conditions in root zone, but drought can appear, often in the same year and in the same area. Due to the small runoff conditions, terrain modeling of flat areas are important, which are influencing the runoff pattern. This runoff pattern is modified by horticultural techniques and by the weed patches. In order to determine the micro relief characteristics of the soil, sometimes special instruments and high vertical accuracy are needed, which are provided by developed technological elements (global positioning system, geographical information system and remote sensing).

We have evaluated the micro relief features and spatial and temporal development of weeds on an intensive apple orchard on the Study and Regional Research Farm of the University of Debrecen (lat.: 47.592508; long.: 21.639914), Hungary. The experimental plot is situate in an area of semi-arid climate conditions. This study area was 1,500 m^2, the soil type is light sandy. Elevation values were measured by Leica ScanStation C10 3D laser scanner, which provided millimeter accuracy spatial data. The so-called laser point cloud contained more than 36 million of points (24,167.44 pts/m^2). This high spatial resolution dataset was suitable to detect the micro morphological features of the soil surface, so micro watersheds and runoff condition were defined and evaluated.

Besides the laser surveying, we have measured the soil compaction with penetrometer to complete the runoff conditions data. Spatial and temporal changes of weed coverage was investigated by GreenSeeker 505 vegetation index meter to evaluate the effect of runoff of soil. The instrument measures the vegetation activity on the plot area.

Based on the results, it could be determined that the slight slope and soil compactions are important factors for water flow direction, which have influenced the distribution of weed flora even on this flat area. These data can help to decrease the problems of surplus water and drought in the field on extreme flat areas. Acquired data can well approximation after exact calibration.

Keywords

Runoff conditions, weed coverage, terrestrial laser scanner, vegetetion indexmeter

The role of daily precipitation interpolation for the SWAT model performance across different spatial and temporal scales

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Abstract

Ground-based precipitation data are still the dominant input type for hydrological models. Spatial variability in precipitation can be represented by spatially interpolating gauge data using various techniques. In this paper we present two case studies from Poland, illustrating the effect of daily precipitation interpolation on discharge simulation using the semi-distributed SWAT model. The first study was carried out in 11 meso-scale (119–3935 km2) sub-catchments lying in the Sulejów reservoir catchment in central Poland. Three interpolation methods (Thiessen Polygons, Inverse Distance Weighted and Ordinary Kriging) were applied and their impact on daily and monthly flow simulations using SWAT was analysed. In order to test the effect of different interpolation methods, a separate model setup was created using the default SWAT method (Def) based on the Nearest Neighbour approach. The evaluation of methods was performed using a semi-automated calibration program SUFI-2 with two objective functions: Nash-Sutcliffe Efficiency (NSE) and the adjusted R2 coefficient (bR2). The results showed that: (1) the most complex OK method outperformed other methods in terms of NSE; and (2) OK, IDW, and TP outperformed Def in terms of bR2. The differences between pairs of interpolation methods were spatially variable and a part of this variability was attributed to catchment properties: catchments characterised by low station density and low coefficient of variation of daily flows experienced more pronounced improvement resulting from using interpolation methods. The second, ongoing study is conducted at larger spatial scale in the framework of the CHASE-PL (Climate Change Impact Assessment for Selected Sectors in Poland) project. The effect of interpolation of daily precipitation using the Kriging with External Drift (KED) method is compared with the Def method in 20 sub-catchments (500 – 194376 km2) of the Vistula and Odra basins. . A similar approach (as in the first study) of evaluating the KED and Def methods is conducted and the preliminary results suggest that applying KED improves an overall SWAT model performance, although the results are spatially variable. In the second study the KED method showed significant improvement in the SWAT model simulation results. The implication from both studies is that appropriate consideration of spatial precipitation variability (often neglected by model users) that can be achieved using relatively simple interpolation methods can significantly improve the reliability of model simulations.

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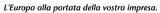We would like to thank the following conference sponsors:

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