SWAT 2017

June 28 – 30 | Warsaw, Poland





Book of Abstracts



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

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

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Foreword

The organizers of the 2017 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 Warsaw University of Life Sciences (SGGW) Water Centre along with Jarosław Chormański, Mikołaj Piniewski, and the rest of the local organizing committee in Warsaw 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; SWAT remote sensing applications; sediment, nutrients, and carbon; 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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Intercomparison of climate change impacts and uncertainties simulated by multiple hydrological models in 12 large river basins worldwide

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Abstract

An intercomparison of climate change impacts and uncertainties simulated by nine regional-scale hydrological models for 12 large river basins on all continents was performed in the framework of the ISI-MIP project. The models ECOMAG, HBV, HYMOD, HYPE, mHM, SWAT, SWIM, VIC and WaterGAP3 were applied in the following basins: Rhine and Tagus in Europe, Niger and Blue Nile in Africa, Ganges, Lena, Upper Yellow and Upper Yangtze in Asia, Upper Mississippi, MacKenzie and Upper Amazon in America, and Darling in Australia. For calibration and validation of the models the WATCH climate data for the period 1971-2000 were used. The models performance, evaluated with 14 criteria, was mostly satisfactory, except for the low flow. Climate change impacts were analyzed using projections from five General Circulation Models considering four RCP scenarios. Trends were evaluated for three variables: the long-term mean annual flow and high and low flow percentiles Q₁₀ and Q₉₀. The robust trends were found for two or three variables in the Lena, MacKenzie and Ganges basins (positive) and in the Tagus (negative). The mean and low flows display decreasing trends in the Rhine, and high flows in the Rhine and Mississippi show increasing trends. The analysis of projected streamflow seasonality demonstrated increasing streamflow volumes during the high-flow period in four basins influenced by monsoonal precipitation (Ganges, Upper Amazon, Upper Yangtze and Upper Yellow), an amplification of the snowmelt flood peaks in the Lena and MacKenzie, and a substantial decrease of discharge in the Tagus (all months). The overall shares of uncertainty in the multi-model ensemble applied for all 12 basins were 57% for GCMs, 27% for RCPs and 16% for hydrological models.

Keywords

climate change, model intercomparison, trend analysis, shares of uncertainty

Calibration of a Brazillian watershed using MODIS evapotranspiration data

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Abstract

The Soil and Water Assessment Tool (SWAT) has been used for evaluating land use changes on water resources worldwide, and as many models, SWAT requires local calibration, but in some places, acquiring high quality data to process with it can be very expensive. So this abstract presents a remote sensing approach for calibrating SWAT model using MODIS evapotranspiration. The watershed of the Pontal River is located at western of the state of Pernambuco, Brazil, between the coordinates 08° 19 '00'S, 40° 11' 42'W and 09° 13' 24'S, 41° 20 '39"W, and occupies an area of 6,057 km²that corresponds to 6.12%. During delineation step, we established 59 well distributed subbasins covering all Pontal watershed. Calibration was performed to each one of them using evapotranspiration (ET) calculated with Level-1B (L1B) radiance MODIS product and the SAFER (Simple Algorithm For Evapotranspiration Retrieving). The parameters chosen to calibrate the model were CN2.mgt, FFCB.bsn, SOL_AWC.sol, SOL_K.sol, ESCO.hru, CANMX.hru, EPCO.hru, GSI.plant.dat. After 1800 simulations using SWAT-CUP software in a HPC windows cluster, we observed an average Nash Sutcliff index (NS) of 0.63 varying from 0.4 to 0.75, and an average Kling-Gupta efficiency (KGE) of 0.76 varying from 0.4 to 0.85. All parameters presented high sensitivity to the model.

Keywords

SWAT model, remote sensing, sensitivity analysis

Hydrologic modeling of sparsely gauged West African river basins using SWAT – a remote sensing approach

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Abstract

Large parts of West Africa are under threat of water stress and high uncertainties exist concerning the availability of freshwater. Since the livelihoods of large parts of the population depend on rain-fed agriculture, accurate knowledge of the water availability is crucial for planners and water resource managers. Hydrologic modeling of water resources is an important tool to support sustainable water management. If the uncertainties of the model results are assessed and communicated correctly, simulations of the water balance may be invaluable to decision makers and water resource managers.

Ground-based observation networks are sparse in western Africa and a further decline in station numbers due to a variety of reasons has been observed in recent years. Remote sensing and global datasets present an alternative, with a multitude of products on climate, topography, land use and soils being freely available and in most cases usable with only minimal training. However, iterating hydrological models with global data sets may result in uncertain predictions. Therefore, it is important to quantify uncertainties in the assessment of water resources caused by uncertain model parameters, boundary conditions, and discharge observations.

In this study, we explore the possibility of using the semi-distributed, physically-based hydrological SWAT (Soil & Water Assessment Tool) program to model the major river basins in West Africa on the sub-national scale (about 3.4 Mio. km²) using remote sensing- and global datasets as inputs. The model was run at a monthly timestep for the period of 1998 to 2013 and calibrated/validated using 64 discharge gauges, where two thirds of the data was used for calibration and one third for validation. Further validation was conducted by comparing the potential-and actual evapotranspiration of the calibrated model to globally modeled and observed data respectively. Changes in water storage were furthermore compared with GRACE data. First results are promising and comparable to earlier studies conducted in the region, underscoring the possibilities of using freely available remote sensing data to assess water resources at the sub-national scale. In some areas however, uncertainties remain high due to insufficient knowledge of local conditions as well as model uncertainties.

This study is part of the COAST project (Studying changes of sea level and water storage for coastal regions in West-Africa using satellite and terrestrial data sets) of the University of Bonn, supported by the Deutsche Forschungsgemeinschaft under Grant No. DI 443/6-1.

Keywords

SWAT, remote sensing, West Africa, large scale

Multi- step distributed SWAT model calibration using remote sensing ET and gauge flow data. Case study of the Upper Blue Nile basin.

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Abstract

Abstract: SWAT has been widely used by hydrologists as a tool to build hydrological models which were applied to study different aspects of water resource management. In many applications SWAT models are calibrated for flow at the outlet of a catchment. This might not insure proper simulation of the different components of the water balance which could be important in some applications like ground water surface water interaction. Advancement in Remote Sensing (RS) technology brought many global Evapotranspiration (ET) products and advancement in computational power brings an opportunity to use these ET products for distributed model calibration. Performance of global ET products varies regionally. Trambauer et. al. (2014) compared eight global ET products over the African continent, from their comparison Global Land Evaporation Amsterdam Model (GLEAM) was found to perform better for our study catchment, Upper Blue Nile (UBN) basin. Thus for this study we used GLEAM_v3.0b ET dataset, which has a spatial coverage for the region 50°N-50°S spanning for the period 2003-2015 at a daily time step (Martens et al., 2016). In our multi step distributed model calibration, we first conduct sensitivity analysis for ET using LHO-Oat method(van Griensven et al., 2006) then we calibrated the selected parameters for ET. We used HydroPSO (Zambrano-Bigiarini et al., 2013) tool for model calibration, we had to modify part of the code which read subbasin output file as we used multiple subbasins for calibration instead of one subbasin as implemented in the original code. At third step we did sensitivity analysis for flow on the remaining parameters and finally we calibrated the model for flow. For our analysis we used high performance computation facility at vrije universiteit brussel, where the current cluster is composed of a total of 153 nodes hosting about 1200 cores with 32 to 256 GB of RAM per node.

Keywords

GLEAM ET, SWAT calibration

Assessment of climate change impacts on blue and green water resources availability in a large scale basin by using CMIP5 model (Case Study: Kashafrood River Basin, Iran)

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Abstract

Hydrology cycle of river basins and available water resources (Such as blue and green water) in arid and semiarid regions are highly affected by climate changes and rainfall pattern. In this study, the impacts of climate change on virtual water parameters in Kashafrood River (KR) as a large scale basin in north east of Iran was evaluated. In this study, soil and water assessment tool (SWAT) model was used in combination with the sequential uncertainty fitting program (SUFI-2), considering sensitivity and uncertainty analysis in five runoff stations to calibrate and validate model. The water availability based on the changes in Blue Water (BW), Green Water Flow (GWF) and Green Water Storage (GWS) was analyzed by MIROC-ESM model in series of the Coupled Model Intercomparison Project Phase 5 (CMIP5). These parameters were compared by two Representative Concentration Pathways of new emission scenarios (RCPs: RCP2.6 and RCP8.5) downscaled based on the observed data under three future periods: near future (2014-2042), intermediate future (2043-2071) and far future (2072-2100) in comparison with earlier (1992-2013). The results of calibration and validation at five stations show good performance of the SWAT model in modeling hydrological processes in this basin. Results of the impacts of climate change on blue and green water components show that in historic period, the basin was not in an appropriate climate condition to access the water resources. Also, in future times, considerable spatial variations in different hydrological components were observed. On the other hand, in both RCPs and all future periods, the blue water contents will increase about 46-74% and green water flow will decrease about 2-15% in relation to preceding period. The results show that the conditions of basin will improve but the green water storage tended to increase about 11-18% or decrease about 6-60% in the future. The blue water and green water flow will decrease and green water storage will increase by changing from near to intermediate-future. Whereas, blue water and green water flow in RCP2.6 will increase and in RCP8.5 will decrease respectively and green water storage in both RCPs will be decreased by changing from intermediate to far-future as well.

Keywords

Keywords: Climate Change; Blue and Green water; SWAT; SUFI-2; CMIP5; RCPs.

Applying the Soil and Water Assessment Tool (SWAT) to estimate impacts of land use and climate change on water resources in a data scarce catchment in Tanzania

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Abstract

Demographic development, global change effects, climate anomalies and degradation of soils in combination with stagnating or even declining food production in East Africa will result in a shift from traditional upland cultivation to an increased agricultural utilization of wetlands. This article addresses the issue of quantifying the water resources of an exemplary wetland and its surrounding catchment under changing conditions to enable a sustainable use of the wetland.

The Kilombero catchment is a subbasin of the Rufiji Basin in southwestern Tanzania with a size of about 40,240 km². It is characterized by high relief energy and a distinctive data scarcity which are typical features in East African catchments.

The SWAT model was applied to ensure an adequate accounting of water resources. The model was calibrated from 1957 to 1965 (R²=0.85, NSE=0.85, KGE=0.92) and validated for the period from 1966-1971 (R²=0.80, NSE=0.78, KGE=0.87) with the SUFI-2 method on a daily resolution. Especially groundwater controlling parameters were found to be very sensitive. Spatiotemporal patterns indicate a clear distinction among wet and dry season as well as between wetland and the enclosing catchment. The temporal extension of all simulations and scenarios stretches from 1957 to 2060 and includes changes in land use and climate.

For climate impact studies, CORDEX Africa data were downscaled to the study area. Land use changes are simulated by using decadal land use maps generated from LANDSAT images from the 1970s up to 2014 in 60m and 30m resolution. Additional land use scenarios range from reforestation scenarios to large scale agricultural intensification with significant shifts in the water balance.

Keywords

SWAT, climate change, land use change, East Africa, wetlands

Can water resources management alleviate the uncertainty of projected climate change impacts on river discharge? - A comparative study in two hydrologically similar catchments with different level of management

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Abstract

Climate change impact studies are associated with error propagation and amplification of uncertainties through model chains from global climate models down to impact (e.g. hydrological) models. The effect of water management, which reduces discharge variability, is often not considered in climate change impact studies. Here, we investigated how water resources management influences discharge variability and uncertainty propagation of climate change scenarios by combining the analyses of observed flow records and model-based climate change impact simulations. Two neighbouring catchments, the Schwarze Elster River (Germany) and the Spree River (Germany and Czech Republic) which are similar in climate, topography and land use, but different in terms of water resources management were chosen as study area. The intense water resources management in the Spree River catchment includes a high reservoir capacity, water use in terms of mining discharges and water withdrawals by power plants as well as water transfers.

The analysis of historical flow records focusses on variability indices (Parde index, Richards-Baker-Flashiness Index, Interquartile Ratio and Baseflow Index). The climate change impact simulations were carried out using a model cascade of (i) the statistical regional model STAR (100 stochastically generated realizations each for 3 scenarios with different prescribed temperature trend), (ii) the hydrological models SWIM and EGMO, and (iii) the water resources management model WBalMo.

The analysis of the observed discharges reveals that the annual discharge variability in the Spree catchment is dominated by mining activities rather than natural rainfall-runoff processes. Due to the high reservoir capacity in the Spree catchment its discharge is characterised by less seasonality and short-term variability compared to the Schwarze Elster. Simulations with climate change scenarios assuming increasing temperature and decreasing precipitation result in pronounced reductions of discharge in both catchments. The differences in potential natural discharges between the Schwarze Elster and the Spree catchments as projected by the hydrological models SWIM and EGMO are marginal. The uncertainties related to the climate projection are propagated through the hydrological models. In the Schwarze Elster catchment, the managed discharges simulated by WBalMo are comparable to the potential natural discharges. In the Spree River however, the short-term variability is moderated by water resources management and managed discharge under climate change is less affected by amplification of uncertainties through model chains.

The results of the study, which combines the analyses of observed flow records and model-based climate change impact simulations, imply that generally, effective water resources management reducing discharge variability

hence also reduces uncertainty related to climate change impacts on river discharge. Catchments with a high storage ratio are thus less vulnerable to changing climate conditions. This underlines the role of water resources management in coping with climate change impacts. Yet, due to decreasing reservoir volumes in drought periods, reservoir management alone cannot compensate strong changes in climate conditions over long time periods.

Keywords

SWIM, climate change, uncertainty, water resources management, model comparison

Impacts of climate change on water availability in Alentejo (Portugal)

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Abstract

Water resources in Mediterranean Europe have been facing major constrains over the past decades due to anthropogenic activities, increasing pollution and reduced water availability. Future changes in climate are expected to aggravate these constraints, through their strong impacts on water resources availability (quantity and quality), on the hydrological and erosion response of watersheds, as well as on crop yields. Furthermore, climate changes may lead to decreases in runoff and streamflow, increases in evapotranspiration and CO² atmospheric concentrations, and shifts in crop growth cycles. Changes in climatological conditions are expected to impact especially Mediterranean regions that are already vulnerable at present. In Portugal, the Alentejo region is particularly vulnerable to future effects of climate change, with particular focus on its water resources availability and despite the existing reservoirs for crop irrigation and for human consumption, which includes the Alqueva reservoir that the largest artificial lake in the Iberian Peninsula with its 4150hm³. Nonetheless, the specific effects of climate change on the reservoirs of Alentejo have not been well-studied.

In this study, we used the SWAT model to evaluate the impacts of climate change on streamflow and phosphorus loads in the Monte Novo and Vigia reservoirs, also in combination with changes in crop types and irrigation requirements in the respective catchments. the Monte Novo and Vigia reservoirs are part of a multipurpose reservoir system and, ultimately, drains into the Alqueva reservoir. The two reservoirs are used, respectively, for urban freshwater supply (district of Évora) and crop irrigation.

The SWAT2012 model was run for 1973-2012 and the calibration routines were conducted on a monthly basis using the SUFI2 algorithm in the SWATCUP, resulting in a good agreement between model predictions and field observations. We simulated different climate change scenarios for 2011-2040, 2041-2070 and 2071-2100, obtained from two regional climate models (RCA4 and RACM022E) in combination with two contrasting emission scenarios (RCP 4.5: moderate; RCP 8.5: more extreme). All climate scenarios foresee an increase in temperature, a decrease in annual precipitation and a shift in rainfall seasonality.

In the case of the RCP 4.5 scenarios, the main impact on water resources seemed to result from an increase in phosphate loads and its potential consequences on water quality. In the case of the RCP 8.5 scenarios, on the other hand, the key impact seemed to be a decrease in inflow. In the Monte Novo reservoir, this inflow decrease was coupled with higher phosphate loads, potentially worsening water quality problems. In the Vigia reservoir, the lower inflow was accompanied by a strong increase in irrigation requirements, worsening the water scarcity situations that are already occurring under present-day conditions.

In conclusion, the SWAT simulations provided important insights that could help decision-makers to review climate change adaptation options ranging from agricultural measures to water reservoir management measures.

Keywords

water availability; climate change; SWAT model

Innovations in Urban Application of SWAT

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Abstract

In the early 2000s the City of Austin Texas identified the need for a continuous simulation hydrologic model for use in urban areas. The model needed to operate on a sub-hourly timestep, simulate stormflow and groundwater interactions, simulate the use of stormwater control measures (SCM) and be sensitive to land use changes. At the time, there was no model that fit these criteria completely. The City entered into a cooperative agreement with Texas AgriLife Research Blacklands Laboratory in Temple, Texas to incorporate changes and upgrades to the SWAT model to allow it to be used for urban application. The City also developed innovative techniques to evaluate hydrologic scenarios with respect to flooding, erosion and aquatic life support. This paper reviews the upgrades to SWAT and the evaluation techniques and summarizes several studies where SWAT was used to examine changes in hydrology as landscape changes from rural to urban, to evaluate development under different regulatory scenarios, to assess total maximum daily loads (TMDLs) in ungauged watersheds and to evaluate different SCM strategies in a fully urbanized catchment.

Keywords

Urban Hydrology, erosion, land use planning

Estimation of streamflow and sediment yield for Watershed Prioritization in the Upper Blue Nile River Basin, Ethiopia

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Abstract

Poor land use planning and management practices have accelerated soil erosion and reduced storage capacity of reservoirs. To mitigate the effect of the increased sediment yield, it is important to identify erosion prone areas for a 287 km² catchment in Ethiopia. The objectives of this study were to: 1) assess the spatial variability of sediment vield; 2) quantify the amount of sediment delivered into the reservoir; and 3) prioritize sub-catchments for watershed improvement using the Soil and Water Assessment Tool (SWAT). Sediment yield was estimated to be 24.26 t.ha⁻¹.yr⁻¹ and model performance indicators showed that SWAT could estimate streamflow and sediment yield at sub-catchment scales under different land use conditions satisfactorily with the Nash-Sutcliffe coefficient of efficiency of 0.77 for streamflow and 0.79 for sediment load. This catchment prioritization study indicated that more than 85% of the sediment was sourced from lowland areas (slope ranging from 0-8%) and the variation in sediment yield was more sensitive to the land use and soil type prevailing in the area regardless of the terrain slope. Contrary to the perception of the upland as an important source of sediments with a steep terrain, low land in fact was the most important source of sediments and should be the focused area for improved land management practice to reduce sediment delivery into storage reservoirs. The research also showed that lowland erosion prone areas are typified by extensive agriculture, which causes significant modification of the landscape. Tillage practice changes the infiltration and runoff characteristics of the land surface and interaction of shallow groundwater table and saturation excess runoff, which in turn affects delivery of water and sediment to the reservoir and catchment evapotranspiration.

Keywords

land use change; watershed prioritisation; reservoir sedimentation; Blue Nile River Basin, sediment yield; SWAT model

Basin-wide water accounting based on modified SWAT model (SWAT-FARS): an application for the Tashk-Bakhtegan Basin, Iran.

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Abstract

Water accounting is an emerging field that aims to provide a consistent approach to analyzing climate-human activity and water interactions. This paper demonstrates the application water accounting plus (WA+) framework based on the modified version of the SWAT model to produce information on depletion of water resources, storage change, and land and water productivity in the Tashk-Baktegan basin. To address this need, a modelling framework, called "SWAT-FARS", was developed to link and integrate SWAT model with the WA+ framework in a basin with intensive irrigation areas. The SWAT-FARS is designed to simulate the complex agro-ecosystems and quantify the irrigation impacts on water cycle and actual water losses in large scale karst basin. Proposed modelling framework shows how integrated simulation of the crop growth and basin hydrologic components can be used for water accounting with WA+. Also the framework is demonstrated how the accounting results can be interpreted to identify existing issues and examine solutions for the future. The results showed that total average annual water depletion in the basin (9.23 km3) exceeded basin water inflows (9.24 km3) during the last decade. This suggest that the Task-Bakhtegan basin is nearly a closed basin in which more than 99 % of the available water is depleted. The managed water use, chiefly dominated by irrigated agriculture, accounts for 28 % of depletion (ET) and about the 60% basin water depletions is vaporized non-beneficially into the atmosphere. Based on the results loss of storage, low beneficial depletion, and low land and water productivity were identified as the main water resources management issues in the case study.

Keywords

Water Accounting+, SWAT-FARS, Depletion, Irrigated Agriculture

Application of SWAT model to assess snowpack development and streamflow in the Nfis watershed, Marakesh, Morocco

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Abstract

Modeling process is often challenging in a mountainous basin and perceiving as difficult due to the irregularity of topography and the complexity of simulation. Snowmelt hydrology is a very important component for modeling applying in watersheds where runoffs are strongly affected by melting snow. In this study, semi distributed (SWAT) model and SWAT-CUP been applied. After collecting data, the whole Nfis watershed located in the Hight atlas of morocco, was separated into 1346 hydrological response units (HRU) in 33 sub-watersheds. Snowpack is an important component of the water resources of the Nfis. The distribution of snow is no-identical through the landscape due to elevation variation as well as number of other factors. Streamflow calibration was done at monthly time steps for the period of 1995–2005, and validated for 2006–2015. Two approaches were used for simulating snow melt process, the temperature index with and without elevation bands. Two validation schemes were analysed: validation considering elevation band and validation without considering the elevation band for precipitation and temperature. The result of this study shows that snowmelt effected on runoff associated with the elevation band better represents the snowmelt-runoff mechanism in terms of Nash–Sutcliffe coefficient and the correlation coefficient R². It clearly explains the effects of temperature and precipitation lapse rates.

Keywords

calibration; performance; snowmelt modelling; Mountain; SWAT; hydrology

The Soil and Water Assessment Tool (SWAT); Review of Global Use and Application Trends Circa 2017

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Abstract

The use of the Soil and Water Assessment Tool (SWAT) has expanded rapidly worldwide during the past two decades. This is evidenced by nearly 3,000 peer-reviewed SWAT-related articles that have been published in hundreds of reputable journals and likely thousands of other studies which have been published in conference proceedings and other formats. The influence of SWAT within water resources research and related disciplines is further confirmed by a variety of recent bibliometric analyses, which reveal the impact that the model has had across a broad spectrum of the scientific community. The impact of SWAT globally can also be seen in the ever increasing types of applications that the model is being applied for including dozens of studies that report some type of code modification, most of which have not been ported to the main SWAT code at present.

Broad indicators of SWAT use are reviewed here including relative use among different countries, regions and continents as well as dominant trends in the peer-reviewed literature including assessment of leading journals and disciplines that are the forefront of publishing current SWAT literature. Key trends in SWAT use are also reviewed including emerging application subcategories such as combined land use change and climate change impact studies, evaluations of bioenergy cropping systems, assessment of crop water productivity or blue/green water analyses, interfaces of SWAT BMP assessments with evolutionary algorithms, impacts of urban BMPs on storm water runoff and pollutant loss and determination of optimal parameter inputs at multi-regional/country levels. Further review is provided regarding applications describing unique modifications to the SWAT code for enhanced simulation of specific environmental conditions including modifications to groundwater or soil layer components, introduction of revised snowmelt algorithms, improved ability to represent rice paddies, advanced nutrient cycling capabilities and revised in-stream functions. The potential to incorporate some of these modifications as well as other potential advancements in future versions of the SWAT+ code are explored.

Keywords

Peer-reviewed literature; Bibliometric analyses; SWAT application trends; Modified SWAT studies

Modifying global precipitation data for enhanced hydrologic modeling of tropical Andean watersheds

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Abstract

Global gridded precipitation is an essential driving input for hydrologic models to simulate runoff dynamics in large river basins. However, the data often fail to adequately represent precipitation variability in mountainous regions due to orographic effects and sparse and highly uncertain gauge data. Water balance simulations in tropical montane regions covered by cloud forests are especially challenging because of the additional water input from cloud water interception. The ISI-MIP2 hydrologic model ensemble (including the SWAT model) encountered these problems for Andean sub-basins of the Upper Amazon Basin, where all models significantly underestimated observed runoff. In this presentation, we propose simple yet plausible ways to adjust global WFDEI precipitation data for tropical montane watersheds. The modifications were based on plausible reasoning and freely available tropics-wide data: (i) a high-resolution climatology of the Tropical Rainfall Measuring Mission (TRMM) and (ii) the percentage of tropical montane cloud forest cover. Using the modified precipitation data, runoff predictions significantly improved for all hydrologic models considered. The precipitation adjustment methods presented here have the potential to enhance other global precipitation products for hydrologic model applications in the Upper Amazon Basin as well as in other tropical montane watersheds.

Keywords

Precipitation, WFDEI, TRMM, Tropical Montane Cloud Forests, Hydrologic Modelling, Andes, Amazon, ISI-MIP

Intercomparison of climate change impacts simulated by regional and global hydrological models in eleven large river basins including quantification of uncertainties using ANOVA

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Abstract

With the increasing importance of climate change in the political debate, also the importance of the models that estimate the consequences of climate change is growing. Their results stimulate the development of international climate agreements and are the basis for the implementation of sustainable adaptation and mitigation strategies. Hydrological models operating at the global and regional scale are available for the quantification of climate change impacts, and for decision makers, it is important to have a systematic comparison of results simulated by the models from both scales, in order to understand uncertainties and to find robust solutions. Other boundary conditions which are constraining the impact results are the emission scenarios and climate model data driving the hydrological assessments. Here, we present a study were we compare hydrological changes simulated by 9 global and 9 regional impact models for 11 large river basins in all continents under reference and scenario conditions. The analysis includes comparison of the validation runs, sensitivity of annual discharge to climate variability in the reference period, and sensitivity of the long-term average monthly seasonal dynamics to climate change. In a second step, the different sources of uncertainty (global climate models, scenarios, global impact models, regional impact models) in projected hydrological changes are quantified and discussed using ANOVA (Analysis of Variance). The work presented is part of the ISIMIP (The Inter-Sectoral Impact Model Intercomparison Project) initiative, a high-level community-driven climate-impacts modelling program providing standardized scenario data and modeling protocols.

Keywords

Climate impact models, global and regional scale, seasonal dynamics, ISI-MIP, model inter-comparison, ANOVA

Software Development Tools for SWAT

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Abstract

SWAT model development significantly concentrates on the user friendliness of the model when interfaced with front end software like ArcGIS or QGIS. This approach makes it really productive for the applied users of these models.

However, purely from the SWAT modeling development perspective, developers can hugely benefit from integrating the latest software development and information technology operations (DevOps) tools like docker containers, virtual box and unit test frameworks. These tools ensure that the model development process is more agile, streamlined and productive.

In this talk, I will discuss the concepts of DevOps, the open source tools relevant for SWAT model and exemplify the advantages of integrating these tools into the model development process. Time permitting, I will also discuss an initial scaling study for parallelization of SWAT.

Keywords

swat model, devops, open source

Development Web-based SWAT LUC with SWAT BFlow Alpha Factor

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Abstract

Land use change is a main factor directly influencing catchment hydrological modeling because these affect various hydrologic components as well as sediment and water quality in watershed. This is especially true in urbanizing watershed. If the hydrological model cannot deal with land use dynamics, it cannot simulate the hydrological phenomena accurately. The CLUE-S model was developed to simulate dynamic land use changes using land use maps, population and topographic data. Unfortunately, most of the models handle land use only in a static state way. SWAT2009_LUC Tool has been developed to overcome this problem in Soil and Water Assessment Tool(SWAT). Although SWAT2009_LUC can consider the temporal and spatial changes of land use, it cannot consider them directly and incorporate new type of landuses. Advanced module, called Land use Update and soil Assessment(LUPSA), was developed by Friedrich J. Koch which can consider land use changes directly and incorporate new type of landuse. Additionally, it can update HRU slopes to simulate detailed land use changes. However, the LUPSA module does not is publicly accessible at this time. Thus the Web-based interface and additional functionalities (SWAT BFlow linkage) were developed to provide user-friendly interface for dynamic SWAT modeling considering spatial and temporal characteristics at a watershed. With this system, developed in this study, SWAT users can consider dynamics of watershed at spatially and temporarily with better accuracies than ever before.

Acknowledge

This work is supported by the Korea Agency for Infrastructure Technology Advancement(KAIA) grant funded by the Ministry of Land, Infrastructure and Transport (Grant 17AWMP-B083066-04).

Keywords

SWAT, land use change, web-based, user-friendly

Bringing two open source worlds closer together - execution and processing of SWAT projects in R

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Abstract

Over the past decades that the Soil and Water Assessment Tool (SWAT, Arnold et al., 1998) is in use, the SWAT community has been developing tools that allow the set-up (e.g. ArcSWAT, or QSWAT), execution, or calibration/validation (e.g. SWATCUP) of SWAT projects to be facilitated and accessible as well as user-friendly. Although, these tools provide a large range of functionalities for a standard modeling work flow, they are often not applicable to new methods and work flows. In such cases, the option to modify the available tools is limited or not provided at all (e.g. with proprietary software).

Script languages, such as R, are gaining in popularity in the natural sciences and many SWAT users employ these for undertaking modifications to their SWAT projects, or in the analysis of model outputs. The possibility to easily produce R packages from sets of R functions and workflows encourages the exchange of useful tools even more. This has the potential to benefit the whole SWAT community.

Over the last years, we developed a handful of R packages for preprocessing and parallel execution of a SWAT model, as well as for sensitivity analysis and visualization of SWAT model outputs. To date, some of the R packages are not published, but they should be freely accessible to the SWAT community within the next months. Since all our developed R packages are open access, we want to encourage a broader community of SWAT users to contribute to the development of SWAT-related R packages in order to adapt their functionality to specific requirements for individual SWAT applications.

GitHub poses a great example of a platform to exchange ideas and collaborate on projects. Therefore, we launched a working group on GitHub to present and host our shared developments in R and to provide ways to collaborate, raise issues, or bring in new ideas to facilitate SWAT modeling work flows.

Keywords

SWAT, Rstats, GitHub, R packages, collaboration

A Comparison of Different Solution Schemes for CSTR-Based Instream Water Quality Simulators Using Hypothetical Experiments and a Real Data

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Abstract

Most common numerical solutions used in CSTR-based in-stream water quality simulators are susceptible to instabilities and/or solution inconsistencies. Usually, they cope with instability problems by adopting computationally expensive small time steps. However, some simulators -such as SWAT- use fixed computation time steps and hence do not have the flexibility to do so. This paper presents a comparison of different solution schemes of QUAL-type water quality formulations for CSTR-based water quality modelling approaches. The methods used in the comparison are three versions of SWAT (the standard SWAT, ESWAT and SWAT-TCEQ), the explicit and semi-implicit fourth order Runge-Kutta methods, the Euler method and a new quasi-analytical solution scheme. The performance of each method is tested for different hypothetical experiments and a real case study. For comparison, we used the growth factors as stability measures and the R-factor as a consistency measure for determining the most robust method. The existing solution method used in the in-stream module of the standard SWAT is well suited for the simulation of water quality variables in cases of short reach discretizations or rapid flow conditions but generally simulates unstable and/or underestimated daily peak concentrations of non-conservative pollutants when the residence time is large and the decay rate is high. Therefore, the in-stream water quality simulator of the standard SWAT may be inaccurate and/or unstable for simulating low flow scenarios if a coarse spatial discretization of the reaches is used. The solution that consists of a fine spatial discretization is obviously computationally expensive. The new quasi-analytical method followed by the SWAT-TCEQ method outperforms all the numerical methods used in the hypothetical comparisons. The semiimplicit 4th order Runge-Kutta method, although has bigger regions of absolute numerical stability with little step size restrictions, provides unstable solutions for rapid flow experiments. An application for the Zenne River (Belgium) shows that the quasi-analytical method provides stable and consistent BOD simulations whereas the standard SWAT model is shown to be unstable for the standard daily computation time step. The quasi-analytical method unconditionally simulates robust solutions. Therefore, it is a reliable scheme for CSTR-based water quality simulators that use first order reaction formulations.

Integration of TUSLE in SWAT model for sediment prediction at a small mountainous catchment, Chenyulan watershed, Taiwan

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Abstract

Climate change becomes more severe due to global warming. In Taiwan, it has been observed that increasing rainfall intensity results in more landslides, debris flows, and flooding at mountainous regions. The Chenyulan watershed, located in central Taiwan was selected in this study. The area of Chenyulan watershed is 448 km² with the elevation ranging from 292 m to 3,893 m. Heavy rainfall brought by typhoons, which hit Taiwan for 3-4 times in a year leads to large amounts of flow and sediment in the watershed. Especially, Typhoon Herb and Typhoon Morakot, occurred in 1996 and 2009, respectively have brought more than 2,000 mm accumulated rainfall in two days, resulting in flooding with the an average of 1,273 and 2,549 cms of streamflow and high observed sediment concentration of maximum 2,000,000 ppm at Chenyulan watershed. In SWAT, MUSLE is used to estimate soil erosion. However, it is not suitable for Taiwan, mainly because of region-specific rainfall erosivity index (R_m) and slope steepness factor (S). Therefore, we integrated TUSLE (Taiwan Universal Soil Loss Equation) into SWAT to calibrate parameters of sediment concentration and export, and further to quantify the long-term influence of high precipitation to sediment export. Moreover, we evaluated the suitability of four different sediment transport methods on sediment prediction on small mountainous catchment in Taiwan: the modified Bagnold equation, the Kodoatie equation, the Molinas and Wu equation, and the Yang equation. The preliminary results showed that integration of TUSLE could estimate sediment export more accurately coupled with the Bagnold equation for sediment transportation. Modelers who conduct sediment studies in the mountainous watersheds with extreme rainfall conditions are suggested to adjust the MUSLE factors and should carefully evaluate the sediment transportation equations in SWAT.

Keywords

SWAT, mountainous catchment, sediment transport, model calibration

Dynamic versus static representations of land use change in SWAT

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Abstract

Representations of land use change in hydrologic modeling studies mostly rely on static land use information of two points in time, even though the availability of dense time series of land use data allows for the incorporation of dynamic land use changes. In SWAT, dynamic representations of land use change can be implemented since 2010. Recently, more SWAT studies have been published that make use of this option. This study aims at analyzing the differences in the modeled water balance caused by dynamic and static representations of land use change. These effects are illustrated with the help of two future land use scenarios and a SWAT model of a rapidly developing catchment upstream of Pune, India. One of the scenarios shows a linear development of land use changes whereas land use changes develop non-linear in the other scenario. The results indicate that the linear dynamic land use development could be better approximated with the static approach than the non-linear development. Nevertheless, also for the linear development the static modeling results pronouncedly differ from the dynamic modeling results in some sub-basins, e.g., overestimation of water yield by 20% in the sub-basin with the strongest increase of urban area. An analysis of the impact of the frequency of land use updates illustrates that it can be recommended to include land use information every five to nine years in a modeling assessment, especially in environments that experience rapid and non-linear changes.

Keywords

Land use change; Environmental impact assessment; Hydrologic modeling; SWAT; India

Evaluating the supply of hydrologic ecosystem services to support the water-food-energy Nexus in the Arno river basin (Italy)

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Abstract

Water, flowing in a basin, underpins key provisioning ecosystem services like freshwater supply, food and energy production. River basin management largely determines the type of Water-related Ecosystem Services (WES) that are provided and the extent to which trade-offs and synergies might arise. Gaining insights on the ecohydrological behavior of a basin and on the conflicting anthropic pressures on the available water resources allows identifying the most important WES, as well as the existence of WES supply and demand hotspots. This information is crucial for water resources management and, in the context of the European Union, also required to comply with the requirements of the Water Framework Directive (WFD).

The purpose of this research is to quantify the main WES in the upstream part of the Arno river basin (Central Italy) and to identify WES hotspots and fluxes. Current information on how water is allocated in the Arno basin remains scarce, despite the increasing water demand by some sectors, particularly irrigation, and a number of emerging conflicts among users. In addition, another main concern is represented by erosion and the potential problems that sediments can cause to the hydropower plant in the basin. The model SWAT (Soil Water Assessment Tool) has been selected because it can integrate the assessment of water quantity and soil erosion in a river basin, representing a useful tool for future testing of best management practices.

SWAT is hereby applied to quantify the distribution in space and time of provisioning and regulating of WES (i.e. water supply for different sectors and sediment yield). The results indicate that the highest amount of water yield, i.e. net amount of water that contributes to streamflow and represents the main blue WES fund, originates in the northern part of the basin, characterized by forest areas. In contrast, the southern part of the basin, which is mainly agriculturally used, gives a minor contribution to the overall water yield, in direct proportion to the precipitation. In order to highlight the role of green water in irrigated land, potential green WES funds are also estimated based on the available soil water content simulated by SWAT. Sediment yield, calculated at the subbasin scale, indicates that the northern part of the basin is the more prone to erosion and thus the main source of sediments that end up filling the hydropower reservoir.

A detailed analysis of the provisioning WES for the different sectorial uses, which represent the actual flow of the WES, has been carried out. Comparing the water withdrawals and the water yield, supply hotspots (areas that are WES funds) and demand hotspots (areas that consume WES) are identified and WES fluxes in the basin are highlighted. This analysis framework supports the understanding of the tradeoffs between different water users, aiming at the improvement of the WES provision within the water resources system. It is expected that research outputs can support the improvement of the existing management framework, moving from the classical DPSIR (Driving forces, Pressure, State, Impact and Response) approach, where impacts must be reduced or mitigated, to a more proactive framework to support the sustainability of the Arno basin and meet the different policy goals.

Keywords

Ecosystem Services, Hydrology, River Basin Management

Impacts of climate and land use changes on the water quality of a vineyard-dominated Mediterranean catchment

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Abstract

Studies that address the potential effects of climate and land use changes on water quality are scarce in the Mediterranean region. In the present work, the SWAT model was used to evaluate the individual and combined impacts of climate and land use changes on nutrient and pesticide export for a small (620 ha) humid Mediterranean catchment dominated by vineyards (São Lourenço, Bairrada wine region, north-central Portugal). SWAT reproduced reasonably well streamflow, sediment yield, total nitrogen (TN), total phosphorus (TP) and total copper (Cu) exports in the São Lourenço catchment under present-day conditions, providing a baseline for investigating climate and land use changes under the A1B and B1 emission scenarios for 2071-2100. Climate changes led to a decline in annual rainfall for São Lourenço (- 12%) but, at the same time, to a strong increase in rainfall during winter (+19%). Associated to the reduction in annual rainfall, there was a decline in annual TN (A1B: - 7%; B1: - 6%) and TP exports (A1B: - 13%; B1: - 12%) under both climate scenarios, mostly due to a decrease in runoff (A1B: - 13%; B1: - 13%) and erosion (A1B: - 11%; B1: - 9%). In contrast, climate changes hardly affected Cu exports (A1B: - 2%; B1: - 1%), which was attributed to Cu's strong immobilization in soils. Land use change scenarios were derived from a socio-economic storyline in which traditional agriculture (e.g. vinevards and pastures) is replaced by more profitable land uses, i.e. corn and commercial forestry. Land use changes led to small increases in streamflow in both scenarios but to changes in water quality that varied markedly between the two scenarios. In scenario A1B, a substantial decrease in TN (-8%), TP (-14%) and Cu exports (-8%) was observed, mostly due to a reduction in vineyards areas. In scenario B1, however, TP exports decreased much less (-5%) while TN exports hardly changed, reflecting differences in the preferential transport pathways of these compounds. Cu exports also remained the same (+0.1%), as no changes occurred in the area occupied by vineyards, which constitute the main source of this contaminant. The combination of climate and land use change scenarios revealed additive impacts on the exports of all three contaminants, emphasizing the importance of integrated approaches to define adaptive land management practices to minimize diffuse source pollution from intensive agriculture.

Keywords

Nitrogen; Phosphorus; Copper; Agricultural pollution; Surface waters

Data generation on the impact of climate change and adaptation measures to support the development of an intensive and sustainable agriculture in the peninsula of Yucatan, México.

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Abstract

In general, it is known that in the Peninsula of Yucatán, México, climate change will negatively impact agricultural production. However, the magnitude of this impact and the positive effect that different adaptation measures could exert to minimize it, is unknown. The organizations: The Nature Conservancy (TNC) and The International Union for Conservation of Nature (IUCN) are developing, under the auspices of the Bonn Challenge (http://www.forestlandscaperestoration.org/sites/default/files/topic/the_bonn_challenge.pdf), a project to generate a strategic program for the development of an intensive and sustainable agriculture with low greenhouse gas emissions in the peninsula of Yucatan. The objective of this work is to quantify the impact of climate change and adaptation measures on the productivity of the agricultural sector of the Peninsula of Yucatan, with the purpose of generating data to support the design of the strategic program above indicated. The magnitude of the impact of climate change on crop productivity was quantified for 12 crops (annual, fruits, grass and forest trees) with and without the use of adaptive measures. The impact was quantified using the SWAT model under the RCP6.0 greenhouse gases emission scenario, during the periods 2001-2010 (baseline), 2050-2060 and 2090-2100. Heat tolerant crops, zero tillage and irrigation, were used as adaptive measures. The results were mapped at municipal scale. It was found that climate change could reduce agricultural productivity by up to 65%, while the adaptation measures studied could minimize only up to 30% of the impact. The combined effect of heat-tolerant crops and irrigation may be the best adaptation practice. With the above information, a menu was developed that shows the areas, crops and technologies most likely to support intensive and sustainable agriculture in the peninsula of Yucatan, México.

Keywords

Simulation Models, decision making, database, climate change

Projected climate change and its effects on mean and extreme runoff in Poland

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Abstract

There is considerable concern that the water resources of Central and Eastern Europe region can be adversely affected by climate change. The Vistula and Odra basins occupying 89% of Poland's territory and parts of neighbouring countries have rather limited water resources compared to other parts of Europe and are increasingly affected by floods and droughts. Projections of future hydrology can be obtained by forcing hydrological models with the output from (global or regional) climate models. In this study, we employed the SWAT model driven with an ensemble of nine bias-corrected EURO-CORDEX climate simulations to generate future hydrological projections for the Vistula and Odra basins in two future horizons (2024–2050 and 2074–2100) under two Representative Concentration Pathways (RCPs): 4.5 and 8.5. The model was extensively calibrated and evaluated for a set of 110 flow gauges showing mean KGE (Kling-Gupta-Efficiency) of 0.68 for the whole set.

Climate projections showed ubiquitous warming of variable magnitude and an overall increase in precipitation (as measured by spatially-averaged ensemble mean) for all time horizons and RCPs. The seasonal pattern was clear, with higher increases over winter and spring than in summer and autumn, but the spreads of projections from different models was substantial, in most cases varying between 10 and 30 %. This was reflected in hydrological projections obtained from SWAT: all 36 climate model – RCP – horizon combinations showed a positive change in mean annual runoff: the highest in winter and the lowest (sometimes negative) in spring. The increasing runoff trend was accelerating in time and correlated with the rate of the climate warming. The spatial patterns showed the highest (relative) increase in the inner, lowland part, and the lowest in the southern mountainous part of the basins. The main mechanism leading to runoff increase is increased infiltration and sub-surface flow components, whereas increases in surface runoff are low.

Projections of future low (high) flow hazard were obtained based on the multi-annual average of the 10th (90th) percentiles of daily flow. Spatially-averaged ensemble mean changes in the low flow indicator varied between 25.8 and 70.1 %, whereas similar changes in the high flow indicator between 14.4 and 36.7 %. Spatial patterns were generally similar to those obtained for mean runoff maps. Although the robustness of projections was rather low, the directions of changes were consistent with that simulated by European-scale hydrological models forced with EURO-CORDEX climate simulations. The whole simulation input and output data set ("<u>CHASE-PL – Future Hydrology</u>") has been made publically available for free, non-commercial use in a research data repository. It should be of primary interest of climate impact scientists as well as water managers working on climate change adaptation issues in Poland.

Keywords

Vistula; Odra; EURO-CORDEX, hydrological projections

Multi Model Ensemble for Assessing the Impact of Climate Change on the Hydrology of a South Indian River Basin

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Abstract

The spatio-temporal uncertainty in precipitation, coupled with ever increasing human interventions upon limited land and water resources, necessitates assessment of sustainability of water resources to avoid adverse conditions in the future. In recent years, climate models are considered as effective tool for predicting future climatic conditions due to anthropogenic emissions. Since these climate models brings along with it uncertainties and biases, multi model ensembles, which consist of a group of comparable climate model simulations, have been widely utilized so as to provide useful insights into uncertainty estimates of climate model projections by providing a bound on the range of uncertainty and a range of possibilities to be considered for emission / warming scenarios. The formulation of water resources management decisions often requires coupling of climate models with hydrologic models to provide quantitative estimates of water regime changes at catchment scale. The proposed study employed Soil Water Assessment Tool (SWAT) to assess the implications of climate change on the hydrology and water resources. The study region selected is Vaippar basin located in central Tamil Nadu, which is experiencing a surge of water related crisis. The basin-scale hydrology simulation was done using the downscaled precipitation and temperature outputs from a suite of global climate models (ACCESS1.0, CNRM-CM5.0, CCSM4, GFDL-CM3.0, MPI-ESM-LR, NorESM-M) downscaled using Conformal-Cubic Atmospheric Model (CCAM). This study assessed the hydrological responses of the basin under greenhouse gas emission scenarios RCP 4.5 and RCP 8.5 for Coupled Model Intercomparison Project Phase 5 climate model projections from six GCMs. This is to incorporate possible range of variation in precipitation, streamflow and water yield, which is useful for both short and long-term planning of water resource development projects in the study area.

The results showed that annual water yield increases in future, ranging from 25% to 74% for near-term (2006-40) and 3% to 26% for mid-term (2041-70) for RCP 4.5. While for RCP 8.5, annual water yield varies from -23% to 26% for near-term and 39% to 128% for mid-term. During the early 21st century, sizeable decrease in water yield was observed for most of the models under RCP 8.5 scenario. The study indicated that SWAT model was able to capture effectively the hydrologic conditions for long-term impacts of climate change on the water balance of watershed. Simulation results showed that variability in weather conditions in the form of climate scenarios significantly affected the water yield. The basin exhibited substantial variability in precipitation and water yield among various climate models, and this knowledge of possible hydrologic impacts at the watershed scale with a band of uncertainty brought about by multi model ensembles, can help the stakeholders assess various options in their decision-making process.

Keywords

Climate change, multi model ensemble, SWAT, emission scenarios

SWAT application for water resources management in Khulm watershed, Afghanistan

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Abstract

Afghanistan is essentially semi-arid to desert and most crop production is limited to pockets of irrigable land, with some rain-fed areas in the north and at high-altitudes (FAO, 2017). To consider water resources management for stabilizing crop production, SWAT was applied to Khulm watershed from 2012 to 2015. Khulm watershed is located in the northern region with about 8300km². River discharge and climatic information were obtained from the Ministry of Energy and Water (MEW). There are three stations for river discharge and four stations for weather information. Precipitation, temperature, and humidity are observed at every stations and wind speed is at a station. Solar radiation was started to measure from December 2015, and no information is existed about it before. Instead, the solar radiation data were developed using the Angstrom formula (FAO, 1998) based on data collected by the Ministry of Agriculture, Irrigation, and Livestock (MAIL) and actual sunshine hours collected by MEW in the watershed.

It was understood that the runoff rate at the outlet of the target watershed was about 5.0 % and water resources were limited for irrigation, from the obtained information. At this moment the reproducibility of stream flow achieved slightly lower than satisfactory level in daily bases, because of input data quality. Then sensitivity analyses of stream flow was conducted by using future predictions of precipitation and temperature from ERA-Interim information to understand water resources availability and crop production variation. It was understood that water resources will slightly decrease in average in the watershed, but uncertainty of future predictions are large and it is difficult to conclude specifically. Also it was estimated that crop yield will increase or decrease depending on the scenarios.

Thus, it is concluded that both approaches of more detail simulation with SWAT and field researches are necessary to consider adaptation and mitigation ways against future water resources management.

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Keywords

Water resources, Sensitivity analysis, Wheat production

Effective catchment management of soil erosion for long-term improvement of surface water bodies quality

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Abstract

Erosion processes within the catchment and the transport of sediment result in a loss of volume capacity and hydromorphological changes of the reservoir. This study deals with the Tool for optimal Selection and Allocation (TSA) of the ecoremediation (ERM) measures in the reservoir catchment to improve water quality and reduce storage loss of the reservoir. The TSA tool

enables the introduction of measures to critical source areas (CSA) where they are the most effective and necessary. A sensible sequence and up-to-date checking of preceding steps leads to the design of an optimal solution for treatment of the water body. In order to verify the operation of TSA tool, the Ledavsko jezero reservoir, with a watershed comprising 105.25 km² in NE Slovenia and SE Austria, was selected. With use of the Soil and Water Assessment Tool (SWAT) we were able to determine SCA and to simulate the effects of eight different scenarios on sediment yield reduction. The results showed that CSA occupy 12.2 % of the watershed and that we could reduce inflow of sediment in to the reservoir up to 30.5 %. After the

determination of most effective measures and CSAs, implementation plan can be defined. With this framework we could enable the selection of cost-effective measures and contribute to the long-term improvement of the ecological status of surface waters due to Water Framework Directive and mitigate erosion from agricultural land due to Common Agricultural Policy.

Keywords

sediment, catchment modelling, critical source areas, erosion, ecoremediation

The impact of load estimation procedures on the simulation of nitrogen fluxes in a small mountainous watershed in Germany.

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Abstract

Eco-hydrologic models are valuable instruments in the field of Integrated Water Resources Management (IWRM). They are efficient tools for the development and testing of Best Management Practices (BMP) to improve the quality of surface water and groundwater in watersheds. A prerequisite for the assessment of BMP is a well-calibrated model, which reflects the governing processes in the watershed. The calibration process for nutrient fluxes relies on the quality of the monitoring scheme where nutrient concentrations are fluxes are determined. We apply the recent SWAT version to a small (51km²) 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. During the last twenty years water quality of the river was determined by a monthly sampling scheme. For the period 2009 to 2012 a weekly to bi-weekly sampling frequency as well occasional sampling during storm flow periods complemented the official monitoring.

Based on the results of the official and complementary sampling schemes, we apply different load interpolation and extrapolation methods and assess the impact on the calibration quality of nitrogen fluxes for the SWAT model.

Keywords

SWAT, Load calculation methods, calibration
An assessment of organic carbon exports in an Arctic watershed presenting permafrost using the coupled SWAT model and Carbon modules.

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Abstract

Permafrost represents one of the biggest organic carbon stocks on Earth. Organic carbon is exported from rivers to oceans in two forms, the dissolved organic carbon (DOC) and the particulate organic carbon (POC). Carbon fluxes going into the Arctic Ocean represent 22 to 32 TgC.yr⁻¹. Climate change, by deregulating permafrost properties, could have an impact on these fluxes and could have a feedback effect on climate evolution at a global scale. Climate change could be responsible of a deeper unfreeze of the superficial layer of permafrost soils, which lead to an increase in carbon exports. This study tries to understand the complex processes involved in organic carbon exports by the Yenisei (the sixth biggest river in the world with a mean annual discharge of 558-627 km³.yr⁻¹), a Siberian river presenting the biggest DOC export to the Arctic Ocean, by using the semi-distributed SWAT (Soil and Water Assessment Tool) hydrological model integrating DOC and POC equation exports. The modeling has been performed at a daily time step on the 2003–2014 period and compared with an observations data set at daily time step during flood events and monthly time step outside these periods (Arctic-GRO Project). By a calibration including modification mainly in climate and soil properties, an understanding, a tracing and a quantification of the sediments and organic carbon transfer processes occurring in permafrost are expected. DOC and POC exports equations from Ludwig et al. (1996) and Boithias et al. (2014) have been adapted to the study case and coupled to the SWAT model. The results reveal that the models for DOC and POC can represent fluxes of organic carbon under climatic forcing and that we will be able to quantify these fluxes in a context of climate change by modeling. The simulated results show a high relationship between the unfrozen period and the exported fluxes that are minimum multiply by 10 during the pic events. Moreover, the results show respective average specific fluxes for sediments, POC and DOC of 1.19 t.km⁻².yr⁻¹, 0.07 t.km⁻².yr⁻¹ and 1.71 t.km⁻².yr⁻¹. These fluxes (POC) represent approximately 20% of the total fluxes exported to the Arctic Ocean. It reveals that the returned flows are in the range of previous studies for POC and DOC fluxes at the outlet whereas they overestimate sediments exports and that a modification in the permafrost properties should disturb much more the DOC flows than the sediments and POC flows.

Keywords

Permafrost; Carbon; POC; DOC; Yenisei River; SWAT

Organic carbon and nitrate transfers at a watershed scale with the SWAT + model using landscape units: application to a large watershed in France

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Abstract

In this time of global changes, hydrological models should increase their abilities to reproduce the elements transfer in the water cycle. Disturbance in organic carbon and nitrate exports are expected and a quantification of these exported flows at a watershed scale and at a daily time step is needed. SWAT+ is a completely restructured version of the Soil and Water Assessment Tool (SWAT) that was developed to face present and future challenges in water resources modeling and management and to meet the needs of the worldwide user community. It is expected to improve code development and maintenance; support data availability, analysis, and visualization; and enhance the model's capabilities in terms of the spatial representation of elements and processes within watersheds. The most important change is the implementation of landscape units and flow and pollutant routing across the landscape. Also, SWAT+ offers more flexibility than SWAT in defining management schedules, routing constituents, and connecting managed flow systems to the natural stream network.

In order to implement new equations in the SWAT+ model such as organic carbon transfer equations (SWAT-Carbon) and water and nutrients transfer during overflooding with the Darcy equation (SWAT-LUD), the SWAT+ model has been tested on a large watershed, the Garonne river (50 000 km², France) where the current SWAT model has been applied. We will present here the methodology and the first results comparing the SWAT+ and the current SWAT under different pedo-climatic conditions by testing the landscape units and integrating the SWAT-LUD module and Carbon modules in the SWAT+.

Keywords

Carbon; Nitrate; Nitrogen; SWAT+; SWAT; Garonne River

gSWATCloud Workshop - SWAT Models Calibration over Cloud Infrastructures

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Abstract

The calibration and execution of SWAT models could be supported by the SWAT-CUP application, which is a single user desktop application allowing the processing of a single current model. According with the SWAT model dimension the process requires significant computing resources and some administrative skill of the single user. This workshop presents the gSWATCloud application as a solution for calibration and execution of multiple SWAT models, by multiple users, in a parallel and distributed manner, through the Web browser. The multiple calibration and execution sessions on different and quite large SWAT models are performed remotely over high performance cloud infrastructures. The user controls the multiple SWAT models and multiple running sessions from a simple laptop or PC, without requiring technical knowledge on the computing infrastructure. The gSWATCloud and SWAT-CUP applications interact and collaborate through the input and output files of a SWAT model.

Keywords

SWAT model, hydrological model, SWAT-CUP application, cloud computing, gSWATCloud application

How to improve the representation of nitrate processes and their dynamics in eco-hydrological models?

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Abstract

Nitrate is one of the most important nutrients in agriculturally dominated catchments. The transport of nitrate and its transformations are influenced by many interacting processes, which are driven by different eco-hydrological processes. Acknowledging the current research in hydrological consistency, the different hydrological and nutrient processes need to be considered at the same time in the model calibration. To achieve this, a two-step procedure is provided consisting of a temporally resolved sensitivity analysis of discharge and nitrate parameters and a joint multi-calibration of discharge and nitrate. For these analyzes, the ecohydrological model SWAT (Soil Water Assessment Tool) is used in an agricultural dominated catchment (Treene river, Northern Germany). A better understanding of the modelled nitrate processes can be achieved by analyzing the temporal variations of dominant nitrate parameters with a temporal parameters sensitivity analysis (TEDPAS). TEDPAS provides daily sensitivities for the nitrate parameters. The temporal sensitivity analysis shows that the dominant parameters vary in the annual cycle due to seasonal varying dynamics in nitrate transport and plant uptake.

Following an improved understanding of dominant nitrate parameters and related processes, a new calibration method is proposed which takes all relevant processes controlling nitrate loads into account. For this, a nitrate duration curve (NDC) is developed and used in addition to the flow duration curve (FDC) in the calibration method. Separate performance metrics are calculated for five segments of FDC and NDC to examine the different magnitudes of discharge and nitrate loads separately. Through this separate assessment of discharge and nitrate segments, a model run is detected that represents all phases simultaneously well.

The combination of a better understanding of the modelled nitrate processes by a temporal parameter sensitivity analysis and an adequate representation of all processes through a segmented calibration of discharge and nitrate leads therefore to a better control of how nitrate dynamics are represented in models. With this knowledge, ecohydrological models could be used in a very constrained way in studies for a sustainable management.

Keywords

Nitrate, temporal sensitivity, calibration procedure, FDC, NDC

Development of the Nemunas River watershed model for hydrology, sediment and nutrient calculations

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Abstract

Nemunas River is the major contributory that discharges into the Curonian Lagoon, which is the largest European coastal lagoon. Nemunas River basin is shared by Belarus, Lithuania, Poland and the Russian Federation Kaliningrad Oblast. Agriculture has a significant impact on the status of water bodies in the Nemunas River Basin. Chemicals that enter the river from agriculture and fish ponds are a major source of pollution alongside point source pollution from industry discharges. It is important to be able to model nutrient and other biogeochemically significant dissolved substance contributions that are altering and influencing the ecosystem in view of a better understanding of the dynamics of the Nemunas River and the Curonian lagoon. Several hydrological models (HBV, MIKE, etc.) were applied to the Nemunas River basin in different studies, assessing impact of different stressors on the system. SWAT was also used by Lithuania's ministry of Environment in development of methodic and modelling system of nitrogen and phosphorus load calculation for surface waters of Lithuania. However, none of the previous studies covered the entire Nemunas River watershed in assessing sediment and nutrient calculations. Therefore, the purpose of this study is to create a modeling system for assessing the hydrology, sediments and nutrients of the entire Nemunas River watershed under different land management and climate change scenarios. The study is still undergoing, but several results are already achieved: the hydrological model is developed and applied for climate change assessment, while nutrient calculation modules of SWAT are being set up for the entire Nemunas River watershed to calculate sediment and nutrient discharge.

Keywords

Nemunas River Watershed model, Hydrology, Nutrient, Sediment, Discharge

Application of measured channel cross-section geometries data for flow and water quality estimation

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Abstract

Current SWAT assumes the channel cross-section as a symmetric trapezoidal cross-sections with 2:1 run to rise slope along the channel length and the bottom width of floodplain as five times the top width of main channel. Moreover, SWAT calculates a channel depth and width using the correlation with watershed area, which was derived from the topographic characteristics of rives in US. This being so, this assumption and regression equations are not valid for a mountainous country such as S. Korea and Asian nations. Thus, the objectives of this study are to 1) evaluate the regression equations for channel width and floodplain estimates in current SWAT, 2) apply the measured channel geometries data using aerial photograph and 3) evaluate its impact on estimation of streamflow and water quality. The top width of main channel and the bottom width of floodplain calculated from current SWAT and measured using aerial photograph were different, especially in the bottom width of floodplain. The flow velocity and depth of main channel calculated from current SWAT and the measured channel geometries also showed difference. There was very little difference in streamflow at the outlet of the whole watershed. It is because total volume of water which was stored in the main channel on the same day is same. However, water quality showed a little big difference, especially suspended sediment and NO2 because most source of water pollutant is sensitive to flow velocity. Following the results of this study, it is recommended that the channel geometries estimation module of current SWAT should be modified to apply SWAT for mountainous watersheds.

Acknowledge

This work is supported by the Korea Agency for Infrastructure Technology Advancement(KAIA) grant funded by the Ministry of Land, Infrastructure and Transport (Grant 17AWMP-B083066-04).

Keywords

SWAT, Channel cross-section, Channel geometries, water quality

How do hydrological processes change in their spatio-temporal relevance under changing climatic conditions?

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Abstract

Hydrological processes vary in their relevance in space and time. Due to that, also the sensitivity of parameters in the SWAT model underlies spatio-temporal dynamics. Sensitivity analyses can be used to improve process understanding and to derive typical temporal patterns of dominant parameters as a fingerprint of catchment behaviour. It can deduced how realistic the processes are represented, which is a requirement for reliable model simulations of current and future conditions.

At first, typical process patterns are derived along a landscape gradient from lowlands via uplands to alpine catchments in Germany. For this, the SWAT model (version SWAT3S with two active aquifers and one inactive aquifer) was applied to four contrasting mesoscale catchments (500-1000 km²).

Using a temporally resolved sensitivity analysis for twelve parameters, the dominant ones were calculated for each day. Using the same parameter sets in the simulations for the four catchments, typical patterns of temporal dynamics in processes and parameters are compared. The comparision of parameter and process relevances shows that the SWAT model is able to reproduce the process dynamics realistically. Moreover, similarities and differences between the catchments are derived. While high flows are controlled by different fast runoff components, low flows are controlled in all catchments by the SWAT groundwater module. The process dynamics in the alpine catchment is largely different from the other catchments.

Following on the simulations for recent conditions, the major input variables – precipitation and temperature – were consistently modified. By using the modified input data, the sensitivity analysis is repeated with the same parameter sets. The resulting model runs were interpreted again in terms of spatio-temporal process and parameter dynamics. A comparison with the results for current conditions shows the climate impact on the process relevance. It is shown whether the changes are continuously or rapidly occurring.

An increase in precipitation leads to a higher relevance of the parameters related to fast runoff processes. Due to the landscape gradient within the four catchments, different parameters are relevant in periods of higher precipitation amount. An increase in temperature reduces the relevance of snow parameters, while fast runoff and evapotranspiration parameters become more important. Our study shows that subsequently also the ranking of the most important parameters can change under changing climate. This can have an effect on the selection of model parameter values in calibration approaches.

Keywords

Sensitivity analysis, Climate change, Catchment comparison

A comprehensive sensitivity analysis for discharge and nitrogen loads involving multiple model input factors

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Abstract

Integrative models, such as the Soil and Water Assessment Tool (SWAT; Arnold et al., 1998), are useful to assess the impacts of system changes (e.g. climate change or land use change) on water balance components, nutrient loads and other environmentally relevant variables. To draw well informed conclusions from the model outputs, a profound knowledge on the sensitivities (and respective uncertainties) of model input factors is essential. We developed a flexible sensitivity framework for the SWAT model to enable a comprehensive analysis of the influences of individual impact factors on any model output variable. In this context, an impact factor can be any model input that can affect the model output, from a single parameter to scenarios (represented by a specific set of parameters or model inputs) to entire model setups or structures.

In this case study we present a comprehensive sensitivity analysis of the impact factors future climate, land use, and urban water management development simultaneously with the SWAT model complexity and model parameter equifinality for different variables of discharge and nitrogen load. We set up the SWAT model for the Austrian catchment of the river Raab. The set up included six different representations of the catchment, each with a varying degree of complexity. By applying a Global Sensitivity Analysis and Monte Carlo filtering we identified the sensitive model parameters for all of the model setups and developed parameter sets that reproduce discharge and nitrogen loads within the modeled catchment equally well. In total, 22 RCP8.5 and RCP4.5 climate change scenarios stemming from a suite of RCM climate change simulations from the EURO-CORDEX initiative for the period 2071 to 2100 were applied to the Raab catchment. For the same time period we developed agricultural land use change scenarios and scenarios for municipal and industrial point source emissions in the catchment.

In a final step, we included all the developed model input factors into the proposed sensitivity framework. The STAR sampling (Razavi and Gupta, 2016) was applied to sample an adequate set of input factor combinations and to analyze the variability (sensitivity) of relevant signature measures of discharge and nutrient loads for changes in the input factors. This sensitivity test allowed us to compare the factors to each other to determine a relative ranking of their overall sensitivity. The presented case study of the river Raab can act as a proof of concept for the proposed sensitivity framework and demonstrates an efficient tool to study questions related to the sensitivity and relevance of specific model inputs for case studies using SWAT. The sensitivity framework will be available to the broader SWAT community soon with the R package SWATpasteR.

Keywords

global sensitivity analysis, discharge, nitrogen, climate change, land use change

Correction and informed Regionalization of Precipitation Data in a high mountainous Region (Upper Indus Basin) and its Effect on SWAT-modelled Discharge

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Abstract

High resolution climatic datasets based on gauge station records are the primary input to spatially distributed rainfall-runoff models for water balance calculations. Among these, precipitation is the most important climatic variable, as it has a direct relation with the catchment discharge. The two major issues, especially in case of hydrological modelling studies, are the possible sparsity in data sampling points (gauge stations), and the discontinuities in data quality of the temporal precipitation records.

The precipitation data for the Upper Indus Basin (**UIB**) also suffer from these problems, as the data has very low spatial coverage, with very little data available at high altitudes, as well as that the available data are uncorrected raw precipitation readings and need checking for quality issues and correction for losses. Another issue discovered during the assessment of the precipitation data for the **UIB** was that the precipitation amounts based on the available gauge stations were unrealistically low to sustain the observed discharge at the basin outlet, as the observed average basin precipitation amounted to only 452 mmy⁻¹, while the observed discharge was 818 mmy⁻¹. Similarly, when the observed precipitation data was used as input the estimated flow generated by SWAT model showed considerable underestimation. Based on these findings one can conclude that the sparse and low to moderate elevation gauge stations data are not representative of the higher elevations of the basin.

To address these issues, a three step approach was carried out. The first step included correction of systematic errors in the raw precipitation data according to two methods recommended by the World Meteorological Organization (WMO). The first correction method (M1) is based on work of Richter (1995) while the second correction method (M2) is suggested by Ma et al (2015). Both these methods use slightly different equations for accounting wind-induced errors, wetting losses, evaporation losses and trace amounts. In the second step, an interpolation of precipitation was done, followed by adjustments for regional specific orographic effects based on the hydro-climatology and the glacier mass balance dynamics, reported in the UIB. In the third and final step, precipitation data sets generated after application of these two correction methods as well as through the subsequent interpolation and regionalization were evaluated and validated based on the hydrologic response generated when using this data as input in the SWAT hydrological model.

The results showed that when the raw-observed precipitation data was used, the SWAT- modelled annual discharge had very low **NSE** and **r**², and very high relative bias (**NSE**: 0.28, **r**²:0.76 and **%Bias**: -47.3). However, the estimated discharge improved a little when classical interpolated (Kriging) raw-observed precipitation data was used (**NSE**: 0.44, **r**²:0.61 and **%Bias**: -33.1).

On the other hand, although the data generated by applying the correction method M1, did not induce any improvement in the SWAT estimates (rather degraded it), much better results were obtained when precipitation data acquired through interpolation and incorporation of regional precipitation laps-rate was used (**NSE**: 0.66, **r**²:0.66 and **%Bias**: -10.7). The estimated discharge by SWAT model further improved when "Elevation Grids" were applied in SWAT to further regionalize the precipitation data with topographic elevation.

The data generated by applying the correction method M2, induced notable improvements in **NSE** and **r**² of the SWAT estimates, but relative bias still high (**NSE**: 0.51, **r**²:0.70 and **%Bias**: -44.0). The results improved further when precipitation data acquired through interpolation and incorporation of regional precipitation laps-rate, was used (**NSE**: 0.68, **r**²:0.69 and **%Bias**: -11.7). Finally, the best results with **NSE**: 0.88, **r**²:0.88 and **%Bias**: 1.6 for the SWAT- estimated discharge were achieved when the option "Elevation Grids" was also turned on in the model.

These results show that correction and improvement in the spatial coverage and scale of precipitation data can be obtained by incorporating knowledge of the regional hydro-meteorology and glacier mass balance (in case of glaciated catchments), which not only improves the quality of the data, but may also lead to better performances of hydrological models driven by such data.

Keywords

Interpolation, Glacier mass-balance, Rainfall-runoff models, SWAT, Precipitation laps-rate, Elevation grids.

Analytic Element Method (AEM) and its Relevance with Subbasin/ HRU Concept of SWAT for Potential Integration of AEM Based Simple Ground Water Model

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Abstract

The Analytic element method (AEM) is a numerical method that gives an approximate analytical solution to a problem. In general, the analytic element models have potential as powerful screening tools that can facilitate or improve calibration of more complicated finite difference and finite element models. This paper explains the concepts of Analytic Element Method (AEM) and its relevance with the Subbasin/HRU concept. The demand for fresh water is increased due to enormous pressure on agriculture and domestic sectors due to population explosion, urbanization, industrialization, expansion of agricultural activities and in-stream water uses. Among all the hydrologic processes, the surface water (SW) and ground water (GW) interactions are said to be a complex processes. In the recent years, the use of Ground Water (GW) in connection with Surface Water (SW) is gaining importance as an effective water management strategy in the water stressed regions. Soil and Water Assessment Tool (SWAT) and MODFLOW/FEFLOW are the two types of hydrologic models used as effective tools to overcome the issues pertaining to water stressed areas. Often, the models are coupled for understanding the SW-GW interactions. But the major drawback in integrating these models is in its conversion from HRUs/Sub-basins to Grid/Elements. These models uses Partial Differential Equations (PDEs) to compute GW dynamics solved by numerical techniques, often leading to huge computational time. Further, in order to couple both SW and GW models, often a translation system is required to move the inputs and outputs back and forth between these models because of different methods of discretization. Thus, to cater the needs of integration, application of AEM to GW modelling may be require relatively less computational effort in contrast to MODFLOW and FEFLOW techniques. AEM based GW model seems to be ideal for coupling with SWAT due to its innate character to consider the HRU, sub basin, river, and lake boundaries as individual analytic elements directly.

The basic premise of AEM is the superposition of analytic functions known as analytic elements within a grid independent domain. Each of these functions represents a particular feature [i.e., abstraction well, a river, a polder, an infiltration area, inhomogeneity, etc.] which is to be modelled and the elements are superimposed independently of other elements to allow the simulation of SW-GW interaction. AEM concept resembles the classical Boundary Element method (BEM), as it does not rely upon discretization of volumes or areas in the modelled system, only internal and external boundaries are discretized. The basic distinction between the AEM and BEM is that the boundary integrals are calculated analytically. Moreover, the AEM provides continuous solution of piezometric head and discharge at any region of interest in the model domain. Also, the computational effort in the AEM does not depend on the size of the model domain rather on the number and complexity of modelled hydrologic features. However, the major limitation is that AEM can be used only when the equations are linear, differentiable (which satisfies either Laplace or Poisson equation) and can be applied predominantly for steady and to a limited set of transient conditions. This paper explores the feasibility for developing a framework to integrate an AEM based simple ground water model with SWAT for modelling the ground water in a simple yet realistic manner

Keywords

Analytic Element Method, HRU, Subbasin, Surface water, Ground water, SWAT

Development SWAT model for contributing basins to Lake Erie from Canadian side and evaluate the effects of inputs on hydrological budgets and streamflow

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Abstract

In the last decade, Lake Erie between United States (US) and Canada (fourth-largest lake of the five Great Lakes in North America) is under serious threat due to increased levels of harmful pollutants from agricultural fields. In 2011, the algae blooms in Lake Erie were exceedingly high and the summer of 2015 produced the largest algae bloom in 100 years. This degradation is projected to worsen with continued anthropogenic climate and landuse change. The contributing basins (appox. 45,000 sq.km) to the Lake Erie from the US side has been modeled extensively using SWAT and is being used by decision makers to implement policies. The entire contributing basin (appox. 25,000 sq.km) from Canadian side has not been simulated with SWAT model.

Various inputs for SWAT model are available from various local (prepared by Canadian agencies) and global (international agencies) sources. There is a need to analyze various available inputs and how they affect various hydrological budgets and determine best inputs to model contributing basin to Lake Erie by comparing with measured streamflow data at various locations. The paper presents comparisons of hydrological budgets and streamflow from changes associated with DEM, soil, landuse/land management and weather acquired from local and global sources.

Keywords

SWAT, Lake Erie, Inputs, hydrologic budjets, streamflow, large scale modelling

Impact of climate change over Saudi Arabia

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Abstract

Saudi Arabia is witnessing the impacts of global warming. Precipitation over Saudi Arabia is controlled by two main wind regimes, the winter (October to March) northerlies, and the summer (April to September) monsoonal wind regimes. The global monthly Climate Prediction Centers (CPC) Merged Analysis of Precipitation (CMAP) data (spatial resolution: 2.5° × 2.5°; temporal resolution: monthly; operational period: January 1979 to November 2011) were used to investigate the nature and magnitude of precipitation variations over Saudi Arabia throughout 1979-2010. Trends in CMAP-derived precipitation patterns were examined over the winter and summer seasons throughout Period I (1979-1995) and Period II (1996-2010). Reversals in precipitation patterns were observed in Periods I and II, where areas witnessing an increase in precipitation in Period I showed a decrease in precipitation throughout Period II, and vice versa for the remaining areas. My findings suggest: (1) an increase in precipitation during Period I over the southeastern and southwestern coastal areas of Saudi Arabia that is probably related to the intensification of the monsoons at the expense of the northerlies, (2) an increase in precipitation during Period II over the northwestern and southeastern of Saudi Arabia is here attributed to intensification of the northerlies, and (3) the general similarity of annual trend patterns to the summer trend (Period I) and to winter trend (Period II) suggest that the annual trends are largely controlled by monsoonal wind regimes in Period I and by the northerlies in Period II. Outputs (i.e., precipitation) of climatic models (CCSM4.0) over the Saudi Arabia are being extracted (for upcoming 100 years), downscaled, and correlated with Period II precipitation trends to investigate whether the observed precipitation trends in Period II mark the onset of global warming-related climate change.

Keywords

Climate Change

SWAT application in Economics of Hydropower - a national assessment

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Abstract

In this paper, we apply the SWAT discharge simulation coupled with econometric methods to estimate the performance of hydropower plants on a national scale in Vietnam - a hydro-dependent country with a diversity of terrain and climate conditions. A watershed is formed from three large inter-boundary basins: Red River, Vietnam Coast and Lower Mekong River with a total area of 977 964 km². These are then divided into 7,887 subbasins with a mean area of 131.6km² (based on level 12 of HydroSHEDS/HydroBASINS datasets) and 53,024 HRUs. River flow is simulated for 40 largest hydropower plants across Vietnam from 1995 to mid-2014, coinciding with the period when both power supply and power demand rose quickly and hydropower played a prominent role in the national power source. Simulated flow appears to be a good proxy for the inflow into hydropower dams and is able to capture 87.3% of the variation in monthly generation. We find evidence of the existence of a cascade effect for electric dams with large reservoirs providing potential resilience to the national power supply when there are adverse impacts from climate change.

Keywords

SWAT, hydropower, economics, Vietnam, climate change, cascade, national scale, Red River, Lower Mekong River, Vietnam Coast

Open data for climate impact modelling in Poland: geoportal ClimateImpact.sggw.pl

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Abstract

Historically, poor availability of free (observed and projected) climate data in Poland has been a limiting factor for climate impact research. For this reason within the framework of the Polish-Norwegian <u>CHASE-PL</u> project (Climate change impact for selected sectors in Poland) several high-resolution hydrometeorological data sets were developed and described in numerous scientific publications. In order to make the underlying data available to various end-users, the web-based map system ("geoportal") <u>ClimateImpact.sggw.pl</u> was created in two language versions (Polish and English). This is the first portal of this type in Poland, whereas the alternative portals available at European scale typically contain lower resolution or lower quality data. The geoportal stores country-wide data (i.e. thousands of interactive maps) concerning:

- 5 km resolution gridded observations of precipitation and air temperature for the time period 1951-2013;
- changes in observed temperature and precipitation indices between the periods 1961-1990, 1991-2013, 1971-2000, 1951-2013;
- bias- corrected projections of temperature and precipitation changes for two future periods, 2021-2050 and 2071-2100 based on the ensembles of regional and global climate models;
- the SWAT model simulation results for the Vistula and Odra basins under different climate change scenarios.

The main functions of the geoportal include:

- download of climate observations and projections data;
- interactive selection of maps based on monthly, seasonal or multi-annual data;
- possibility of browsing and value identification of four seasonal and one annual map simultaneously.

The web-map application was based on the ArcGIS Server developed in two levels architecture: REST for sharing data and JavaScript API for user-to-server communication and visualization. Additionally, <u>ESRI Geoportal</u> <u>Server</u> was launched for metadata management purposes. While the geoportal presents interactive data on monthly, seasonal and annual time scales, the corresponding daily data are freely available in a research data repository <u>4TU Centre for Research Data</u>. It is expected that the new data sets together with the geoportal have the potential to attract more researchers to study the hydrological impacts of climate change in Poland. They should be of interest of water managers and water-sector policy makers in the context of climate change adaptation. They should also attract attention of regional impact modellers from other disciplines than hydrology, e.g., agricultural modellers (e.g., with respect to projected changes in soil moisture and water availability for irrigation) and freshwater ecologists (e.g., with respect to projected alterations of streamflow that may affect freshwater biota). In the future, the geoportal could be used for presenting data on climate change impacts on other sectors, such as agriculture, wetlands, tourism etc. Since in its current form it is supposed to serve different groups of users with different needs, in the future some customization could be made in order to better meet the requirements of different groups.

Keywords

climate change, geoportal, flow projections, Poland, open data, GIS

SWAT Weather Database: A Support Tool for the Long-Term Analysis of Climate Scenarios with SWAT

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Abstract

The hydrologic cycle and the weather are closely related and, as a consequence, so is climate. In the era of the Anthropocene, however, climate is not any more understood as purely the result of physical processes, but as an outcome of complex interactions between human and natural systems: climate change being an obvious example. As the consequences of human actions in social-ecological systems become clearer in the Anthropocene, new approaches are required to describe the connections and feedbacks between human and natural systems. At the regional level and under a watershed management perspective, socio-hydrology is a novel science that acknowledges the need to, over long time-scales (i.e. decades), holistically study the dynamics of coupled humanwater systems, usually explored by means of scenario analysis. In climate change science, the study of different climatic pathways relies on the usage of quantified weather information coming from both general circulation models and regional climate models. In socio-hydrology, however, this information is used as inputs for climate scenario analysis (and possibly multi-model ensemble) as drivers of regional hydrologic cycles at a watershedlevel. A regional hydrologic model that can be used to assess the hydrologic-related consequences of coupled human-water systems is the SWAT model. One of the main challenges in performing the long-term analysis of climate scenarios with SWAT is the need of preparing an extensive weather database, resulting from: information covering a time-span of decades; multiple climate scenarios, and; multi-model forcings. Aiming at supporting the utilisation of the SWAT model in a context of long time-scale analysis, this paper presents the SWAT Weather Database, a tool that has been developed to assist SWAT users to manage weather data and in performing longterm analysis of climate scenarios with SWAT. The tool is currently capable of: i) Storing daily weather information; ii) Supporting the creation *.txt* files to be used as input information during an ArcSWAT/QSWAT project set-up, and; iii) Allowing the batch calculation of the Weather Generator – WGEN statistics of several weather stations in one-step run

Keywords

SWAT; Weather database, Weather Generator; Long-term Analysis

Response of Randomized Subsets of Rainfall Gauges Over a Paraná River Sub-basin

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Abstract

Accurate rainfall data are critical for precise representation of temporal and spatial uncertainties of climate characteristics in hydrological modeling. The choice of a homogeneous version of a flung network of precipitation stations is a great deal. Non-climate factors can lead these data to become unrepresentative. To investigate the impact of station arrangements, this study aims finding an optimal density of rain gauges and determine possible errors during a hydrological simulation. The Ivaí River basin, a Paraná River catchment, was selected to this goal. Clusters of gauges were chosen by randomizing 175 stations available in Water National Agency inventory. The arranged hypothetical scenarios were used as input for simulation with the Soil Water Assessment Tool (SWAT). The simulation with 175 stations was considered as the base scenario. Model performance was quantified and compared with the base scenario. Results showed that streamflow predictions obtained with decreasing number of stations in the arrangement is almost linear up to 30 remaining stations. For arrangements involving less than 30 stations, the predicted streamflow is severely noncorrelated. Furthermore, a threshold as low as one station per 10^3 km² has enough ability to create a good representativeness of streamflow; emphasizing that in a station network, data quality is more decisive than quantity. It was also identified that topography is determinant as a non-climatic inhomogeneity that can lead to misinterpretation of simulated results. In addition, it was found strong correlation between topography and accumulative precipitation (0.764) and simulated flow rate (0.801). By other means, stations placed in higher altitudes lean to overestimate flow rates or vice versa. Data adjustment must be carried out to compensate biases that inhomogeneities in station arrangements may produce or enlighten inherent error over hydrological modeling.

Keywords

Hydrological Modeling; Rainfall Station Density; Ivaí River.

Hydrological Response of a Brazilian Catchment to Different Land Use and Land Cover Products

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Abstract

The soil-atmosphere interaction is determinant in establishing climatic patterns and their associated effects. Studies have shown that changes in land cover modify evapotranspiration and cause significant impacts on the flow regime. In this study, this effect was evaluated by applying the Soil Water Assessment Tool (SWAT) to a catchment of the Paraná River Basin (Upper Rio Grande), with an area of 26,490 km² and a mean flow of 312 m³s⁻¹. The simulations were performed using three different land cover files: MODIS, GLOBCOVER and a local product developed from Landsat satellite (30m resolution). The study was divided in three basic steps: i) development of Land Use and Land Cover (LULC) product from Landsat imagery; ii) assessment of the accuracy of LULC using the Kappa Index and; iii) hydrological simulation for the three LULC scenarios with SWAT. The results showed a wide discrepancy among the assertiveness of the LULC products. The Pasture was the most representative class in the Landsat product (about 55% of the area), while for MODIS was the Savanna class (about 75%) and for GLOBCOVER the Agriculture class (about 65%). The product of LULC from Landsat was the most accurate (Kappa Index - 0.73). As for the simulations, the Landsat product generated the most accurate results, generating an mean flow of 369.9 m³s⁻¹ for the basin (GLOBCOVER - 379.5m³s⁻¹ and MODIS - 379.1m³s⁻¹). The results suggest that different LULC databases produce divergent flow rates. This demonstrates that knowing the physical characteristics of the region is fundamental to simulate hydrological regimes.

Keywords

Hydrological Modeling; SWAT; Satellite Imagery.

An adaptation to the vegetation growth module of SWAT for tropical condition

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Abstract

The Soil and Water Assessment Tool (SWAT) is a globally applied river basin eco-hydrological simulator in a wide spectrum of hydrological studies. Yet, the vegetation growth module of this model requires adaptations for simulating the seasonal growth cycles for trees and perennial vegetation in tropics, where the major plant growth controlling factor is the rainfall (via soil moisture) rather than temperature. The objective of this paper is to improve the vegetation growth module of the SWAT model for simulating the vegetation indices such as the leaf area index (LAI) for tropics realistically. Therefore, we present a modified SWAT version for the tropics (SWAT-T) that uses of a simple but robust soil moisture index (SMI) – a quotient of the rainfall (P) and reference evapotranspiration (PET) – to initiate a new growing season after a defined dry season. Our results for the Mara Basin (Kenya/Tanzania) show that the SWAT-T simulated LAI corresponds well with the Moderate Resolution Imaging Spectroradiometer (MODIS) LAI for evergreen forest, savanna grassland and shrubs, indicating that the SMI is a reliable proxy to dynamically initiate a new growing cycle. The water balance components (evapotranspiration (RS-ET) and observed flow. The SWAT-T simulator with the proposed improved vegetation growth module for tropical ecosystem could be a robust tool for several applications including land use and climate change impact studies.

Index-based analysis of climate change impact on ecologically relevant flow regime

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Abstract

Climate change is expected to affect the flow regime, cause loss of habitat, reduce biodiversity, change the community composition and behavioral habits of fish. The impact of climate change on ecologically relevant streamflow conditions for fish in the Vistula and the Odra river basins in Poland was assessed. Streamflow simulations obtained with the Soil and Water Assessment Tool for the historical period and two future horizons were driven by a set of nine bias-corrected EURO-CORDEX Regional Climate Models under two Representative Concentration Pathways of greenhouse gas concentration trajectories. This study identified a subset of Indicators of Hydrological Alteration (IHA) that are ecologically relevant for three ecological groups of fish in Poland. An index-based framework was developed in order to estimate the impact on fish in future climate conditions. The model's uncertainty was addressed through a aggregation method which assessed the dominant direction of change and identified the inconsistencies in the model's response. The amount of river reaches where streamflow conditions for fish are highly impacted by climate change varies between 53.3 % and 69.5 % in RCP 8.5 in 2071-2100. Projections of climate change impact on fish driven by relatively "wet" climate change scenarios suggested predominantly medium and high impact.

Keywords

Climate change, fish, Indicators of Hydrologic Alteration, Poland, streamflow, SWAT

Integration of SWAT and QUAL2K for water quality modeling in a data scarce basin: a case study of Cau River basin of Vietnam

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Abstract

Water quality modeling in a river basin often face the problem of large data set and limited available data. The important inputs to the water quality model are pollution concentrations and discharge in river tributaries, lateral flow and from point and diffuse pollution sources in the river basin. In general, completion of such a data set is hardly established, especially for data scarce basins as it can be found in many developing countries. In that case, the work for water quality modeling become more difficult. However, in many cases, an integration of models may be able to fill this gap. Depending on the available data of river basin, selection of models should be made. For the case study of Cau river basin, stream flow for ungauged tributaries and lateral flow are obtained by well calibrated SWAT model, while observed pollutant concentrations data from field survey campaigns (2010-2015) are used as boundary inputs for water quality model QUAL2K. Using this approach, the water quality model for mainstream of Cau river can be constructed. The model has been calibrated and validated satisfactorily using recent data sets. The obtained results can be used to support water quality management and control in the Cau river basin.

Keywords

Model Integration, water quality modeling, data scarce, SWAT, QUAL2K

Effect of climate change on hydrology, sediment and nutrient losses in two lowland catchments in Poland

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Abstract

Future climate change is projected to have significant impact on water resources availability and quality in many parts of the world. The objective of this paper is to assess the effect of projected climate change on water quantity and quality in two lowland catchments (the Upper Narew and the Barycz) in Poland in two future periods (near future: 2021-2050, and far future: 2071-2100). The hydrological model SWAT was driven by climate forcing data from an ensemble of nine bias-corrected GCM-RCM runs based on the EURO-CORDEX experiment. Hydrological response to climate warming and wetter conditions (particularly in winter and spring) in both catchments includes: lower snowmelt, increased percolation and baseflow and higher runoff. Seasonal differences in the response between catchments can be explained by their properties (e.g. different thermal conditions and soil permeability). Projections suggest only moderate increases in sediment loss, occurring mainly in summer and winter. A sharper increase is projected in both catchments for TN losses, especially in the Barycz catchment characterized by a more intensive agriculture. The signal of change in annual TP losses is blurred by climate model uncertainty in the Barycz catchment, whereas a weak and uncertain increase is projected in the Upper Narew catchment.

Keywords

climate change effect, sediment, nutrients, SWAT, water quality

Quantification of risks and costs of climate change impacts on floods and droughts in the Danube basin

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Abstract

An increase of hydro-climatic extremes can be observed worldwide and is challenging national and regional risk management and adaptation plans. The Future Danube Model is a multi-hazard and risk model suite for the Danube region that is currently developed in cooperation with the insurance sector. It consists of modules for estimating different perils such as heavy precipitation, heat waves, floods, and droughts under recent and future conditions considering climate change and possible adaptation measures. The weather and climate module uses observed and regional climate model data to produce, using a probabilistic approach, long-term daily weather time series as they are representative under current and future climate conditions, for the historical period and two future periods. All in all 200,000 years of climate projections are produced which can be directly used to assess the likelihood of future changes in extremes. They serve as input to the hydrological model SWIM (Soil and Water Integrated Model). It translates the weather input under current and future conditions into daily river discharge for more than 13.000 river reaches in the Danube basin but also into other hydrological quantities. It is used to assess the changes in future flood frequencies and drought recurrence. The risk module translates the hydrological extremes into financial losses. High-resolution 2D simulations are necessary to derive inundation depth, return period and if required flow velocity maps as flood intensity metrics. Multi-variable damage functions for residential buildings and private households are prepared to be applicable across a range of spatial scales using European-wide available data and/or local specific data to estimate losses for affected assets. A webbased Geographic Information System is used to visualise the simulation results.

As a result, The Future Danube Model provides spatially consistent information on extreme events and natural resources throughout the entire Danube catchment, which can be used for risk management, implementation of EU framework directives as well as for urban and land use planning, water resources management and climate proofing of large scale infrastructure planning.

Keywords

Climate change, hydrological extremes, floods, droughts, risk assessment, insurance

Climate change impacts on meteorological, hydrological, and agricultural droughts in semi-arid regions of Iran

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Abstract

Semi-arid regions of Iran have been seriously affected by frequent droughts in hydrological and agricultural sectors. Climate change is expected to exacerbate the situation. This study aims to assess the impact of historic and future meteorological, hydrological, and agricultural droughts using the standardized precipitation index (*SPI*), standardized runoff index (*SRI*), and standardized soil moisture index (*SSWI*), respectively, in Karkheh River Basin of Iran. The severity and probability of occurrence of each index were aggregated separately to obtain a holistic drought hazard index (*DHI*). Variables required for calculating drought indices were obtained from a SWAT (Soil and Water Assessment Tool) model calibrated and validated for the study area. Daily bias-corrected Global Circulation Models (GCMs) under two scenarios of Intergovernmental Panel on Climate Change (IPCC) scenarios were fed into SWAT to extract future variables. Historic results showed that agricultural and hydrological droughts occurred with 3 month-lags. Future projections show a decrease in the frequency and duration of meteorological drought, while an increase in the hydrological and agricultural droughts. Agricultural sector shows highest exposure to drought intensity, which resulted in higher vulnerability of wheat yield to drought. We concluded that the combined application of SWAT with drought hazard indices and vulnerability concept helps to better understand climate risks to food security and facilitates the development of adaptive measures to reduce drought impacts.

Keywords

climate change, drought hazard index

Application of SWAT model to compare simple and complex bias correction techniques for climate change analysis

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Abstract

There is no doubt that corrections are required, before analyzing the impacts of climate change at a regional level. In recent years, with the development of complex bias correction techniques, simple bias correction techniques are getting overshadowed. Such complex model has an advantage of correcting not only the mean but also, standard deviation, frequency and intensity of precipitation, however, the complex techniques are often time and effort consuming. Since most of the water resources analysis are performed at monthly resolution, where daily fluctuations are averaged out, the question was, are the simple techniques are still useful? Therefore, this study takes an effort to compare the simpler Linear Scaling Bias correction (LS) against a comparatively complex Quantile Mapping Bias correction (QM) at monthly resolution. The bias corrected data from both technique was used as an input for the calibrated hydrological SWAT model of the Kali Gandaki River Basin of Nepal. This study confirms SWAT to be suitable model for hydrological analysis in Nepalese Himalayan basins at daily resolution. Also, it can be concluded that simpler LS is as effective as QM at monthly resolution. In addition, simple techniques offer dual benefit – easy to learn enveloping larger research community, and saves resource including time and effort. Thus, at coarse resolution studies, one can argue simple bias correction techniques to be more beneficial instead.

Keywords

Bias correction, Himalayan Basin, linear scaling, quantile mapping, SWAT

APEX model simulation of edge-of-field water quality benefits from upland buffers

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Abstract

For maximum usefulness, simulation models must be able to estimate the effectiveness of management practices not represented in the dataset used for model calibration. This study focuses on the ability of the Agricultural Policy Environmental eXtender (APEX) to simulate upland buffer effectiveness for reducing P export. The study used 16 years of monitoring data (1993-2008) from three field-scale row crop watersheds: upland agroforestry buffers (grass plus trees), grass buffers, and control (no buffers). The data were split into two datasets: prior and after buffer establishment in the fall of 1997. Objectives were to: i) calibrate and validate APEX on each dataset, ii) evaluate the performance of APEX on the dataset for which it was not calibrated and validated, and ii) compare estimated buffer effectiveness with that calculated from monitoring data. After modification of the APEX code to improve simulation of infiltration in the buffers, we successfully calibrated APEX for event runoff and total P using each dataset. The model based on the prior buffer dataset performed poorly once buffers were established. In contrast, the model developed for buffer conditions performed adequately for runoff and TP for a scenario with no buffers. Buffer effectiveness was similar when estimated using a paired watershed approach using monitoring data or values simulated with the model based on the buffer dataset. Effectiveness estimated with the model based on the prior buffer dataset. Buffer is proved using APEX to evaluate conservation practices not included in the calibration dataset.

Keywords

edge-of-field, buffers, APEX

The Agricultural Policy/Environmental eXtender (APEX) Model: Recent activities, model development, and plans

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Abstract

The Agricultural Policy/Environmental eXtender (APEX) model was developed for continuous simulation for whole farm/small watershed management and can evaluate various land management strategies considering sustainability, erosion (wind, sheet, and channel), economics, water supply and quality, soil quality, plant competition, weather and pests. APEX has been in constant evolution since its first appearance in 1995 with continued support by federal and state agencies. Notable recent developments include: 1) preferential grazing practice adapted from PHYGROW, 2) paddy rice management, 3) variable soil hydraulic conductivity method for improved soil moisture simulation, 4) and bacteria fate and transport processes in manure applied fields, and 5) dynamic simulation of shallow aquifer storage with groundwater irrigation. Forthcoming development includes integration of other simulation, PHT3D for simulating reactive transport calculation, KINEROS for modeling lateral overland flow, Southern Oscillation Index method for incorporating climatic variability in WXGEN/SPEGN, and pest dynamics.

This paper presents recent and future development of APEX and supporting tools; summarizes notable publications; and reports recent APEX training activities.

Keywords

APEX

Nutrient Delivery and Agricultural Conservation Effects on Water Quality in the Des Moines River Watershed

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Abstract

The Des Moines Watershed (DMW) in the Iowa is an important agricultural basin with 71% of the agricultural area, and drains into the Mississippi River. DMW is one of the major contributors of nutrients from Iowa to the Mississippi River. This watershed is affected by agricultural nonpoint source pollution especially higher nitratenitrogen loads from its sub-watersheds. Government initiatives, local partnerships, and research programs are ongoing in this basin to reduce nutrient loads and support the designated uses. A modeling study was undertaken recently to determine the effects of current and future agricultural conservation strategies on water quality. The field-scale model, Agricultural Policy Environmental Extender (APEX) was used to simulate the conservation practices on cropland and Conservation Reserve Program land and assess the edge of field water quality benefits. The watershed scale model, Soil and Water Assessment Tool (SWAT) was used to simulate non-cropland land uses, watershed processes and estimate the instream water quality benefits after integration of the APEX outputs. After calibration for streamflow, sediment and nutrient loads at multiple stations, models were used to estimate the effects of various cropland conservation practice strategies on water quality. APEX simulations indicated that about 8.0 million tonnes of sediment, 86,000 tonnes of nitrogen, and 5,560 tonnes of phosphorus losses were occurring at the edge of field in the DMW under 2012 conservation condition. SWAT simulations indicated that 2.7 million tonnes of sediment, 59,400 tonnes of nitrogen, and 3,380 tonnes of phosphorus loads were discharged from the DMW to the Mississippi River. Several alternative agricultural conservation strategies were simulated and analyzed. The Enhanced Nutrient Management with Drainage Water Management reduced the edge of field sediment, nitrogen, and phosphorus losses by 59%, 37%, and 38%. The same conservation strategy reduced the sediment, nitrogen and phosphorus loads discharged to the Mississippi River by 14%, 33%, and 16%. This study will provide insights on how far agricultural conservation help to achieve nutrient reductions and support in addressing hypoxia and TMDL.

Keywords

SWAT, APEX, Conservation Practices, Des Moines Watershed, Sediment, Nitrogen, Phosphorus

Analysis of spatial distribution of observed ground-based data and large scale modelling of the Parana River Basin

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Abstract

The Paraná River Basin (PRB) is one of the largest watersheds in Brazil with the drainage area of around 879,873 km² and with a population of more than 60 million inhabitants. In addition, PRB has a great importance in the economy and development of Brazil, which contributes to agricultural and livestock development, public and industrial supply, and power generation. In the last decades, several studies have demonstrated a significant increase in streamflow in PRB. However, some regions of the basin have witnessed severe hydrological droughts. In this sense, the main aim of this study was to evaluate the spatial distribution of solar radiation, wind speed, temperature, relative humidity and rainfall over PRB, and modelling its streamflow using the Soil and Water Assessment Tool (SWAT) model. 30 years of climate data observed by the National Water Agency (ANA), the Department of Water Electrical Energy (DAEE) and National Institute of Meteorology (INMET) were used. The model was run during the period Jan 1984 to Dec 2013. The results of this work will present a discussion of spatial distribution of climate variables, which will be used as input data and constitute the most important driving in watershed models, as well as the ability of the model in representing the discharge of PRB.

Keywords

SWAT, hydrological modelling, climate dataset.

Predicting Drought in an Agricultural Watershed given Climate Variability

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Abstract

Changes in the future hydrologic cycle due to changes in temperature (T) and precipitation (P) are likely to be associated with increases in hydrologic extremes. This study evaluates the impacts of climate variability on drought using the Soil and Water Assessment Tool (SWAT) in Goodwater Creek Experimental Watershed (73 km²) in Missouri, USA. The Standardized Precipitation Index, Standardized Streamflow Index, and Z-score based soil moisture index were computed for historical data to quantify meteorological, hydrological and agricultural drought, respectively. The physical values, (e.g., mm precipitation) that corresponded to droughts during the historic period were used to evaluate future drought frequency. The frequency of future drought was predicted using twelve T & P datasets from the Coupled Model Intercomparison Project Phase 5 for the four relative concentration pathways (RCP 2.6, 4.5, 6.0, and 8.5). These data were statistically downscaled at the watershed scale to a finer resolution. After calibration of the SWAT model based on historical data (1993-2010), simulations were run for the future (until 2075) using these climate data. SWAT-simulated streamflow and soil moisture were used to compute drought indices on a monthly basis. Results showed that droughts will occur more frequently in the future than they have during the historic period for the majority of climate model output under all four emission pathways. Multiple indices were analyzed to better understand how future hydrologic changes present risk to different sectors, i.e., water managers and farmers.

Keywords

climate variability, drought, extreme and future

Simulation of the effects different rangeland improvements scenarios on evapotranspiration of Case study: Gorganrud Watershed-Golestan-Iran

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Abstract

Hydrological response of a watershed is a comprehensive symbol of environmental conditions and characteristics of the basin. Vegetation is one of the main factors in water resources status, erosion, and sediment of a watershed. Rangelands of Golestan province, Iran due to the geographical location, climate, and destruction of these resources as well as drastic land use change from forests, and rangelands to agricultural lands, have a high potential of run-off. Therefore, in the present study, in order to determine the best management of the rangelands, we developed a rangeland improvement model using the Soil and Water Assessment Tool (SWAT) in the Gorganroud Watershed, Golestan Iran. Calibration and validation of model was performed using Sequential Uncertainty Fitting Program (SUFI-2) in the eco-hydrological model SWAT. Results of simulating the run-off in the studied hydrometric stations and forage production in the studied sub basins showed that this model was run well for the study area (P-factor 0.5-0.9; R-factor 0.55-1.5). As well, four range improvement scenarios (mechanical, biological, biomechanical, and grazing management scenarios Evapotranspiration was increased to 2.3%, 12.8%, 15.5% and 2.8%, respectively in comparison with actual Evapotranspiration. According to the obtained results, the biomechanical scenario was identified as the best one increasing Evapotranspiration and water conserve in poor and moderate rangelands.

Keywords

Rangeland improvement operations, SUFI-2, Biomechanical scenario, Grazing management, Gorganroud watershed

Hydrological modeling with SWAT under contrasting climate in a semi - arid zone: case of the wadi wahrane, Algeria.

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Abstract

The Mediterranean basin is one of the poor regions in water resources in the world, having suffered from recurrent and severe droughts, especially the North African countries, and they are undergoing climate variability. The use of hydrological modeling can contribute to the study of water resources evolution in the medium and long term in a context of climate change. The aim of this study is to test the robustness of SWAT model (Soil and Water Assessment Tool) on small watershed (269.6 km²) in semi-arid area of the northern Algeria under climate variability. The method used in this study is the D.S.S.T (Differential Split Sample Test) procedure which will allow studying the temporal transferability of parameters and the possibility to use the SWAT model in different climate conditions from those in which it was calibrated.

Statistical tests of homogeneity on the time series of the annual precipitation have enabled us to detect climatic breaks which have led to a considerable decrease in precipitation. From this point on, we have selected two homogeneous sub-periods of 10 years, which they are different according to the interannual mean of precipitation as well as the aridity index, The first sub-period P1 (1973-1983) is wet and the second sub-period P2 (1983-1993) is dry. We used the SWAT-CUP SUFI2 to calibrate and validate SWAT; the model is evaluated according to the Nash criterion. The application of SWAT shows that it can better simulate the monthly and annual runoff than a daily runoff, for that, The DSST was applied on monthly scale. The swat was shown good simulation of watershed response in calibration phase with Nash =70. The model simulated the runoff behavior better when transferred to wetter conditions than to drier. It was shown that the robustness became unacceptable when climate conditions involved decrease in annual precipitation. The reduction in model robustness may be partly due to the inability of the model to take accounts of the interaction between surface water and groundwater. The need to multiply several basins and sub-periods to better exploit the SWAT model can help us to pronounce on its robustness and to apply the long-term climate predictions.

Keywords

SWAT, semi-arid, climate variability, DSST, Algeria.

How uncertainty of simulating water resources is affected by different input data information content

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Abstract

The partly-deterministic model Soil and Water Assessment Tool (SWAT) demands a large variety of spatial input data. These are commonly available in different resolutions and result from different preprocessing methodologies. Effort is made to apply the most specific data as possible for the study area to reflect the heterogeneous characteristics of landscapes. Most often, modelers prefer to use regional data, especially with fine resolution, which is not always available and is computationally demanding. Instead, global datasets are considered that are more general. This study investigates how the use of global and regional input datasets may affect the goodness-of-fit and parameter uncertainty of the model. We analyzed eight different setups for the SWAT model, combining two of each Digital Elevation Models (DEM), soil and land use maps of diverse spatial resolution and information content. The models were calibrated to discharge at two different catchments that are partly located in the north of Luxembourg and partly in the southeast of Belgium. The Winseler catchment area is about 103 km2 and Kautenbach-Clerve is about 232 km2. The regions are considered rural areas, having around 5-8% of urban areas, and the rest is almost equally divided between pasture, forests and arable lands. The Metropolis Markov Chain Monte Carlo algorithm implemented in the python package SPOTPY was used to infer posterior parameter distributions and assess parameter uncertainty. During the optimization process, we are maximizing the logarithmic likelihood and later calculating the Nash-Sutcliffe Efficiency (NSE) and the logarithm of NSE to quantify goodness-of-fitness for high and low flow, respectively. We focused on snow temperature, soil physical, groundwater and main channel parameters. Preliminary results indicate that the model has the best performance when using the regional DEM and land use map and the global soil map, indicating that SWAT cannot necessarily make use of additional soil information if they are not substantially effecting soil hydrological fluxes. Moreover, additional data or missing processes (i.e. the current model structure is not able to cover the dominant hydrological processes) are needed to improve the model's capability in simulating the hydrology of these catchments. Furthermore, all model set ups are underestimating the model uncertainty suggesting that additional source of uncertainties should be estimated simultaneously.

Keywords

uncertainty assessment, Wiltz River, Clerve River, input data
Developing a SWAT Sub-Module for Simulating Dynamics of Cyanobacteria, Green algae, and Diatom

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Abstract

This study modified algal module in SWAT model to estimate the concentration of the specific algal species (i.e. cyanobacteria, green algae, and diatom) in Sangju reservoir basin. The model calibration was done by the SWAT-CUP and provided the acceptable accuracy of flow rate, sediment, TN, and TP loads. The algal module of original SWAT could not have satisfactory simulation results of the three algal species and nutrient contribution after algal die-off due to the over-simplified temperature function. Thus, this study introduced the temperature multiplier function to the current SWAT model. This function specified the temperature effects to identify the seasonal variation of the algal species more realistically. Also, the current model improved nutrient contribution from the algae die-off. The simulation of the three algal species were mainly depend on the light intensity and the temperature. The rapid growth and die-off of cyanobacteria and green algae resulted from the significant difference in the temperature multiplier coefficient. In contrast, the diatom growth showed less seasonal variation. Though the growth rates of the three algae species were relatively higher compared with theoretical values due to the model limitation to consider the biomass accumulation on minor season, the seasonal variation of the species substantially followed with observed data. Consequently, this study will be able to provide a new SWAT module to understand the mechanism and biomass simulation of the critical algal species.

Keywords

Cyanobacteria, Diatom, Green algae, SWAT, Modification, Algal Mechanism

Hydrologic component analysis at the Water Curtain Cultivation site according to annual rainfall pattern

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Abstract

In Korea, a number of Water Curtain Cultivation (WCC) systems have a significant role in groundwater management in shallow aquifers of riverside during winter period. However, there were few long term basis analysis on the water balance of this watershed. This study conducts the hydrological component analysis from 2010 to 2015 at the water curtain cultivation area in Cheongwon-gu, Cheongju-si by using SWAT-K model. The monthly based groundwater recharge variation was also investigated. It is found that the rates of evaportranspiration, surface runoff and groundwater recharge were varied according to the total annual precipitation and their correlations were also changed annually. Annual groundwater recharge rates for annual precipitation ranged from 8.3% to 19%, and their coefficient of determination ranged from 0.39 to 0.94. When the severe drought happened, the lack of groundwater recharge made groundwater level decrease consistently.

ACKNOWLEDGMENTS: This work was supported by a grant (17RDRP-B076272-04) from Infrastructure and transportation technology promotion research Program funded by the Ministry of Land, Infrastructure and Transport of Korean government.

Keywords

Water Curtain Cultivation, SWAT, Hydrological component analysis, Groundwater recharge

Determination of the Environmental Impacts of Agricultural Land Use on Lower Seyhan Plain using SWAT Model

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Abstract

The aim of this study was to determine the impacts of agricultural land use activities on water quality and quantity of Lower Seyhan Plain (LSP) to provide management strategies for sustainable water use. LSP is one of most important agriculture areas in Turkey. It covers approximately 3000 km² and comprises various crop schemes including corn, wheat, cotton, soybean and citrus in a flat area. The quality of water is highly disturbed by these agricultural activities. Moreover, management of water quantity is also the key factor for irrigation schemes in the region. Therefore, water management and agricultural activities have significant trade-offs.

The hydrologic processes and nutrient transport of the region were modelled in five main phases; i) spatial and temporal data analysis, ii) model calibration, iii) implementing SWAT model, iv) model validation, v) assessing the modelling results. SWAT model required a wide data set including climate (temperature, precipitation, wind, humidity), land use, soil and topography. The spatial and temporal data analysis was done using Remote Sensing (RS) and GIS (Geographical Information Systems) techniques to provide available data set for the model. Four main gauging stations were defined as basin outlets. Predefined method was utilized by dividing the LSP into four sub-basins and main drainage canals in each sub-basin was manually digitized to integrate in the model because of artificial drain system and flat surface characteristic. The model was then calibrated and validated using observed runoff data derived from available gauging stations. It was run from 2011 to 2013 for calibration and 2013 to 2016 for validation periods. The preliminary results showed that the total annual runoff was 138,5 m³/s⁻ ¹ for LSP. The Nash-Sutcliffe Efficiency varied from 0.60 to 0.70 for calibration and validation that represented a promising modelling performance for such a complex basin in terms of its morphology and land use disturbances. According to the model validations, the model approach was able to capture the complex interactions between agricultural activities and hydrologic processes. This study has significant importance to reveal the capability of the SWAT to model in a flat Mediterranean plain in which the seasonal changes of water level in drainage canals that are polluted by domestic and industrial waste waters, and fertilization applications.

Keywords

Lower Seyhan Plain, SWAT model, agriculture, land use, water quality

Land use change effects on hydrological regime in the Xingu watershed - Brazil

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Abstract

Accelerated land use change in the Amazon biome over the last decades has raised questions about the extent and consequences of the impacts on the local hydrology. Land cover patterns control surface runoff, infiltration, evapotranspiration and sediment production within the watershed, directly influencing the streamflow dynamics and sediment yield. High deforestation rate at agricultural frontier areas as well as the recent reduction of this rate can significantly affect hydrological processes. The resulting changes on the regional hydrological cycle affect ecosystem function as well as navigation, agricultural activities, power generation and riverside inhabitants, either directly or indirectly. Beyond the scarce availability of hydrologic and sediment data, the Amazon region also lacks studies that establish a relationship between land use and the hydrological system. Applying hydrological models, such as Soil and Water Assessment Tool (SWAT), in the Amazon region is crucial to the analysis of the system's response to future land use and climate change scenarios. The Xingu Watershed (509.000km²), located at the agricultural frontier area of Eastern Amazon is divided into areas of extensive native forests, and areas with differing levels and types of agricultural activities. This watershed has suffered intense deforestation over the last four decades, with expansion of grain cropland and cattle ranching at the southern region of the basin. As of 2004, government policies increased the discipline of environmental legislation which has since partially reduced the advance of deforestation. In this context, this work aims to model the relation between land use and water discharge of the Xingu Watershed using the SWAT model, analysing the impacts of future land use scenarios. To overcome the issue of climate data scarcity, 1998-2016 Tropical Rainfall Measuring Mission (TRMM) data series were used along with data provided by the Brazilian National Meteorological Institute (INMET). Daily streamflow data were obtained from the Brazilian National Water Agency (ANA). Data from the TerraClass project (National Institute for Space Research - INPE/Brazil) were used as land use input, whereas soil physical characteristics data were prepared using pedotransfer functions based on studies and Amazonian soil texture data from Radar da Amazonia Project (RADAMBRASIL) and the Brazilian Soil Survey for Amazonia (EMBRAPA). Simulations are currently being performed on two Xingu River sub-basins: Fresco River sub-basin (43.000km²) and Iriri River sub-basin (142.000km²). Initial results from these simulations suggest a good model fit when simulated flow is compared to the observed flow from fluviometric stations ($r^2 = 0.87$, NS = 0.85). The continuation of this work aims to expand modelling to the entire Xingu Watershed, enabling the simulation of future land use scenarios.

Keywords

Land-use change, streamflow, SWAT model, scenarios, Amazon region, Xingu watershed

Blue water scarcity in the Black Sea catchment: identifying key actors in the water-ecosystem-energy-food nexus

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Abstract

Large-scale water scarcity indicators have been widely used to map and inform decision makers and the public about the use of river flows, a vital and limited renewable resource. However, spatiotemporal interrelations among users and administrative entities are still lacking in most large-scale studies. Water scarcity and interrelations are at the core of the water-ecosystem-energy-food nexus. In this paper, we balance water availability in the Black Sea catchment with requirements and consumptive use of key water users, i.e., municipalities, power plants, manufacturing, irrigation and livestock breeding, accounting for evaporation from major reservoirs as well as environmental flow requirements. We use graph theory to highlight interrelations between users and countries along the hydrological network. The results show that water scarcity occurs mainly in the summer due to higher demand for irrigation and reservoir evaporation in conjunction with relatively lower water resources, and in the fall-winter period due to lower water resources and the relatively high demand for preserving ecosystems and from sectors other than irrigation. Cooling power plants and the demands of urban areas cause scarcity in many isolated locations in the winter and, to a far greater spatial extent, in the summer with the demands for irrigation. Interrelations in water scarcity-prone areas are mainly between relatively small, intra-national rivers, for which the underlying national and regional governments act as key players in mitigating water scarcity within the catchment. However, many interrelations exist for larger rivers, highlighting the need for international cooperation that could be achieved through a water-ecosystem-energy-food nexus.

Keywords

water, scarcity, nexus, ecosystems, energy, food

Parallelization of SWAT calibration: a Windows HPC approach

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Abstract

The Soil and Water Assessment Tool (SWAT) has been used for evaluating land use changes on water resources worldwide, and as many models, SWAT requires calibration, but the execution time of these calibrations can be rather long, not allowing proper analysis. So this abstract presents a windows approach for calibrating SWAT model using a multinodal cluster computer. For that we used six computers with i7 processors (3.2 GHz; 12 cores), 8 GB RAM and 1 TB HDD each one, but the only requirement for this type of cluster is to have 64-bit processors. Our computers were setup with Windows Server HPC 2012 R2, a network switch 10/100, and regular Ethernet cables. We used the project example of the SUFI2 algorithm that comes with SWAT-CUP package to perform calibrations with 100 simulations at node level. Calibration essays were configured as follow: 1-12 (1 process interval), and 12-72 (12 processes interval), resulting in 17 essays. Each essay was repeated there times and presented as the mean execution time, in order to minimize any influence of resources fluctuations. Results showed that time was split in almost half using nine processes (15 min) in relation to the one node control (28 min). We observed a linear decrease of execution time from one to nine processes, and then it increased about 23% and stabilized at 80% of the control. All processing is divided into five steps: distribute files (2.24% of all processing time), organize samples (0.89%), run SWAT (47.59%), collect results (46.51%) and cleanup (0.28%).

Keywords

hydrology model, Brazil, Hydrology monitoring, algorithm

Challenges of Hydrological Modeling in a Basin in Northeast Brazil

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Abstract

Hydrological modeling using SWAT has been carried out in different regions of Brazil, contributing to a deeper analysis of basins and requiring less financial resources for scientific research. However, it comes up against issues related to scarcity or poor quality of data and information, which lead to less efficient modeling. This work aims to present the main issues faced in hydrological modeling using the SWAT model in a Brazilian basin. The Goiana River basin is located in the Brazilian state of Pernambuco, between latitude 07°22'20" and 07°54'47" and longitude between 34°49'06" and 35°41'43", occupying an area of 2,847,53 km². The region holds rainfall stations with a high percentage of errors and non-uniform distribution, the soil mapping has a scale of 1:100,000 and the mapping of land use on a scale of 1:250,000. Due to the lack of high-quality satellite imagery for this area, which has huge cloudiness, the mapping of land use was made with images from 1999 to 2005. The area holds high amount of water reservoirs, however the control agencies do not provide all the information required for the model. It has been verified that the information required for calibration, streamflow and sediments data, are also scarce. Despite the challenges faced, the model presented satisfactory results for some regions of the Goiana Basin, with a Nash Sutcliff index (NS) ranging from 0.62 to 0.82 and PBIAS between 4.43 and -21.53, but in the region with less data spatialization, the values were 0.43 and 17.79 for NS index and PBIAS, respectively. The statistics obtained in the modeling show the applicability of the model for flow estimations in the basin, however, it is necessary to use climatic data from other sources in order to reach a model that can adequately respond to the entire basin. The results of the model were improved by detailing the distribution of agricultural crops based on information from Brazilian agencies. This ratifies the importance of the quality and quantity of available data related to climate and land use in the modeling and demonstrates the challenges faced by Brazilian researchers.

Keywords

Goiana river, Pernambuco, landuse, SWAT model

Understanding of water and nitrogen cycle in an irrigated Mediterranean area in southern Turkey

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Abstract

In arid and semi-arid regions, freshwater resources are under the ever increasing pressure of many current issues such as population increase, economic development, climate change and pollution. Nitrogen leaching from agricultural land is a main pollutant in Turkey. Calculation of N budget in agricultural systems with use of different empirical of statistical methods are common practice in OECD and EU countries. However this methodologies do not include climate and water cycle as part of the process as it is established by Soil and Water Assessment Tool (SWAT) model which was developed especially for modelling agricultural catchments. The study was conducted in Lower Seyhan River Plain Irrigation District (Akarsu) of 9,495 ha in Cukurova region of southern Turkey. Intensive and extensive water and nitrogen monitoring data (2008-2014), soil properties, cropping pattern and crop rotation was used for SWAT model build, calibration and validation of the model. The aim of this study was to improve understanding of: a) the effects of by-pass flows due to irrigation on the calibration of SWAT model, b) irrigation return flow (IRF) and/or drainage generating processes, c) N leaching dynamics with simulation of agricultural land management (fertilisation, irrigation, plant species) under Mediterranean climate conditions. The performance indicators of the modelled flow (R2, NSE and PBIAS) during calibration period of 2009-2012 were 0.62, 0.57 and 6.3 and for the validation period were 0.67, 0.59 and -10.04. respectively. Objective function statistics, R2, NSE and PBIAS in specific, for nitrogen in drainage were defined as 0.47, -0.63 and 88.1% for the calibration and 0.50, -0.20 and 72.9% for validation, respectively. This basin is not natural instead it is a man-made hydrologically well-defined area in a semi-arid Mediterranean region where it is subjected to intensive irrigation and fertilizer applications by anthropogenic activities. Imported N loads by irrigation water, rainfall and mineral fertilizer inputs make the calibration and validation challenging and difficult with relatively weak results. The routine fertilizer applications are exceedingly higher than the recommended levels, i.e., 380 kg N ha⁻¹ is applied to corn while only 240 kg N ha⁻¹ is the expert recommendation for corn in the region. This results in high potential for nitrogen leaching. The SWAT model results helped us to highlight that almost 40% of diverted irrigation waters has been recklessly squandered in the irrigation scheme. It is almost impossible to quantify by-pass flow magnitudes in such irrigation system without using any modelling tools. Furthermore, modelling exercises showed that SWAT model run results were sensitive to crop rotations type due to the fact that runoff by precipitation is low and high due to irrigation applications exceeding 1000 mm per year with mostly flood irrigation type.

Keywords

semi-arid regions, nitrogen leaching, water balance, return flow, by-pass flow, irrigation

Modelling diffuse and point source pollution risks in the case of transboundary Sotla river basin

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Abstract

The study was conducted on the river Sutla, which is a natural border between the Republic of Slovenia and the Republic of Croatia. This study aims to show the SWAT model results of diffuse and point source pollution risks in order to implement measures that could avoid a possible water quality deterioration, which is one of the biggest challenges in water management of this area. In the case of transboundary river basin, the challenge is even greater because of a range of factors related to diversity of water management, backgrounds, approaches, interests and development scenarios for the defined area. The performance indicators of the modelled daily flow (R2, NSE and PBIAS) during calibration period of 2009-2014 were 0.59, 0.61 and -10.58 and for the validation period were 0.54, 0.54 and 0.59, respectively. Monthly calibration objective function statistics NSE for sediment concentration, nitrate nitrogen load and mineral phosphorus load were defined as 0.72, 0.65 and 0.41, respectively. Results show that point sources in normal conditions contribute very small share of N (3.2%) and P (7.2%) on average daily basis.

Keywords

integrated water management, EU water policy, pollution sources, human well-being

Application of the Soil and Water Assessment Tool for hydrological modeling in a High-Arctic catchment: Brøggerelva watershed, NW Spitsbergen

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Abstract

The water balance in Arctic catchments is connected to the presence of permafrost as well as snow and ice masses that largely determine pathways and volume of water flow through the polar landscape. The proglacial and paraglacial streams and rivers of polar regions are therefore very sensitive on present-day climate changes. Understanding and quantifying the relation between local, environmental controls and global climatic influence on water discharge variability and spatial pattern of flow pathways are key challenges to estimate climate change impacts in Arctic and sub-Arctic regions. In this regard, the use of hydrological modeling is crucial. On the poster preliminary results of the SWAT model application in the High Arctic glaciated catchment are presented. The study was carried out in the Brøggerelva watershed which is situated in the north-western Spitsbergen. The catchment covers 32 km² (elevation range 4-742 m a.s.l.) and is circa 50% glaciated by two retreating, cold-based, valley glaciers Austre and Vestre Brøggerbreen, whose thicknesses are below 100 m. The area of the catchment is almost entirely underlain by permafrost with seasonal active layer measuring from 0.5 to 1.5 m. For SWAT modeling we collected spatial data mainly from two sources: archive geodata from the Norwegian Polar Institute and the field campaign during the summer 2016. The simulation time span covered the years 1990-2014. The preliminary results indicate the possibilities and limitations of selected data sources in the build of the SWAT model for the polar catchment. The study was carried out within the project "Late-glacial and present landscape evolution following deglaciation in a climate-sensitive High-Arctic region SLOPES" (RIS-ID 10150).

Keywords

SWAT, Arctic catchment, hydrological modeling, Spitsbergen

Modelling mountain hydrology using the SWAT model to understand the impact of abiotic environmental variables on the health of high altitude aquatic ecosystems

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Abstract

High altitude lakes, wetlands and streams are key habitats for mountain species and they ensure downstream water quality. Despite their remoteness, these ecosystems are subject to environmental degradation and species extinctions. Aquatic and semi-aquatic organisms as invertebrates and amphibians are directly dependent on water quality and quantity and can therefore be seen as sentinel species for studying environmental change. Amphibians in their mountain habitat are of particular concern due to their global decline crisis. Dramatic extinctions have been observed for several decades and are to date explained by a complex combination of causes, including habitat loss and degradation as well as the spread of the pathogenic fungus Batrachochytrium dendrobatidis. Those evolutions have been related to stressors as climate change, land use and land cover changes as well as to the exposure to organic and inorganic contaminants. Important elevation gradients and topographical and climatic variability in mountains create a diversity of habitat conditions, sustaining a rich biodiversity and many specialist species. The objectives of this study is to quantify the impact of abiotic environmental factors on aquatic ecosystem health in different pedo-climatic mountain regions, which are sensitive to changing conditions. Hydrological modelling with SWAT (Soil and water assessment tool) will be used to describe and quantify the dynamics of habitats and to compare the large-scale hydrological and biogeochemical dynamics of amphibian aquatic mountain habitats. Model outcomes will be confronted with data on distribution of sentinel species and pathogen spread. As a first step, this work aims at exploring changes in abiotic factors (e.g. like temperature, discharge) of aquatic habitats using existing data on climate, water quantity, water chemistry, land-use and land cover changes and pollution. Long-term data records for the Pyrenees (France) and the Sierra Nevada (USA) will be analyzed and later compared with existing and newly collected data for the other two mountain ranges. For a better understanding of hydrological processes, SWAT model results will be compared with models operating on smaller scales (e.g. lake-scale). Finally, this work will contribute to tackle questions as for example: Which hydrological and climatic variables (e.g. air and water temperature, water quality) are influencing amphibian disease dynamics? What are specific catchment characteristics that control water quality and pollutant bioavailability? What is the role of latitude, longitude and altitude in aquatic ecosystem health? Insights can help for example in species conservation efforts or protected area management by identifying especially vulnerable areas towards environmental degradation, biodiversity loss and pollutant transfer. Here we will present the first results of data analysis and the global methodology integrating the use of the SWAT model.

Keywords

Mountain hydrology; Pathogens; Abiotic factors; Environmental change; Pollutants

Streamflow calibration of a semi-distributed hydrological model by single and multi-site measured data on the Yuan River Catchment, China

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Abstract

The physically-based hydrological model, SWAT (Soil and Water Assessment Tool), requires quantities of parameters and many of them cannot be measured directly. Therefore, calibration is an essential process in order to generate suitable parameter sets. Single site calibration is only determined by the measured streamflow at the catchment outlet whereas multi-site calibration considers streamflow measured both at and before the outlet. The effect of single and multi-site calibration, evaluated by an objective function, e.g. the Nash-Sutcliffe Efficiency (NSE), varies from catchment to catchment according to previous research. The objective of this study is to find the better approach for calibrating a SWAT hydrological model setup for the Yuan River Catchment (China), whereby utilizing the limited measured streamflow from varied periods, at a monthly step. Three gauging stations, located in the upstream (Site 1), midstream (Site 2) and mid-downstream (Site 3) are able to supply the streamflow for three years. Site 1 and 2 provide data from 2008 to 2010 and Site 3 is from 2012 to 2014. The first two years (2008-2009 or 2012-2013) of the data were applied for calibration while the third year data (at 2010 or 2014) of all three sites were applied during the validation period. Results show that multi-site calibration (NSE = 0.65) generate a more convincing streamflow than the single-site calibration (NSE = 0.59) during the validation period, regarding that the NSE of Site 1 and 2 in single-site calibration were less than 0.5. Due to the interior sites, multi-site calibration is capable of obtaining a more regionalized parameter set and capture more features of the Yuan River Catchment.

Keywords

Single and multi-site calibration, semi-distributed hydrological model, SWAT

Water Resource Assessment, Gaps, and Constraints of Vegetable Production in Ethiopia

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Abstract

Rainfed agriculture supports the majority of the poor in sub-Saharan Africa. However, rainfall variability, land degradation, and low soil fertility lessen their effectiveness for feeding the growing population. This study aims to estimate the water resources potential to sustain small-scale irrigation (SSI) in Ethiopia into the dry season to expand the food supply by growing vegetable and to understand the gaps and constraints of irrigated vegetable production. The case studies were located in Robit and Dangishta watersheds of the Ethiopian highlands near Lake Tana, where detailed field-level data were collected. The study focused on data from 18 households who have been cultivating tomato and onion during the dry season using irrigation. The two components of the Integrated Decision Support System (IDSS) - the Soil and Water Assessment Tool (SWAT) and Agricultural Policy Environmental eXtender (APEX) - were used to assess impacts of SSI at multiple scales. Results suggest that there is a substantial amount of surface runoff and shallow groundwater recharge at the watershed scale. The field-scale analysis within the Robit watershed indicated that optimal tomato yield could be obtained with 450 mm of irrigation and 200 to 250 kg/ha of urea and 50 kg/ha of diammonium phosphate (DAP). In Dangishta, optimum onion yield can be obtained by applying 550 mm irrigation with 120 to 180 kg/ha of urea and 50 kg/ha of DAP. Studying field scale water balance, the average shallow groundwater recharge (after accounting other groundwater users such as household and livestock uses) was not sufficient to meet tomato and onion water demand. The field-scale analysis also indicated that soil evaporation attributed a significant proportion of evapotranspiration (i.e. 60% of the evapotranspiration for onion and 40% for tomato). The SSI intensification adversely affected streamflow at the watershed scale. Use of mulching or other soil and water conservation interventions could increase water for cropping by reducing soil evaporation thereby enhancing the shallow groundwater. Integrated use of shallow groundwater and harvested surface runoff would reduce the negative environmental externalities.

Keywords

SWAT; APEX; IDSS; production function

Changes in runoff characteristics of streams in Jeju Island, Korea due to climate change

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Abstract

A total of 142 rivers are distributed in Jeju Island in Korea, and they are classified as intermittent streams except for 9 rivers including the Gangjeong Stream. In the case of a regular river, the middle-upper stream section except for the downstream section shows the characteristics of intermittent streams which flow out only over a certain amount of rainfall. As a result, annual river runoff rate in Jeju Island is about 20% of rainfall, which is very low compared to 58% of inland areas of Korea. Therefore, it is not easy to identify the geographical and geological characteristics and the rainfall - runoff characteristics, especially the intermittent stream runoff phenomena, of Jeju Island by the modeling method applied in the inland area. In this study, SWAT model was used to analyze the runoff characteristics of the entire Jeju Island and major river basins, and intermittent stream simulation technique that modifies subsurface flow, infiltration and percolation according to the degree of soil moisture was applied to the model. In addition, by analyzing past trends as well as future climate change impacts, we assessed changes in temporal and spatial runoff characteristics over a long period of time in Jeju Island.

Acknowledgement

This research was supported by a grant (code number: 17RDRP-B076272-04) from the Jeju Regional Infrastructure Technology Development Center funded by Ministry of Land, Infrastructure and Transport of Korean government.

Keywords

SWAT, intermittent stream, runoff rate, climate change

Assessment of SWAT model performance in case of Olešná reservoir watershed, Czech Republic

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Abstract

Outer Western Carpathians is geologically formed by flysh belt which comprises mainly from alternating claystone, shale and sandstone beds. Flysh rock is typical for low permeability, thus there is low retention by groundwater storage. As consequence there is need of relatively bigger amount of water reservoirs for providing water resources.

Olešná reservoir serves as source of water for industrial purposes and for recreation as well. In recent years Olešná suffers by drought resulting in lower inflow enhanced by specific geological conditions mentioned above. Additionally due to expected climate change there is probability of increasing drought frequency.

SWAT model was developed for watershed contributing to Olešná reservoir. Issue of input data availability is presented (mainly issue of soil data). Model was calibrated according to daily measured stream flow on gauge located near reservoir and inflow to reservoir during 2007-2011 and validated for period 2012-2015. The performance of model was assessed as good, many errors contributed to peak flow shifting.

Calibrated and validated model will be used as tool for assessment of sediment and nutrients inflow risk (with additional calibration and validation) and for prognosis of potential impact of climate change scenarios.

Keywords

input data, flysh, reservoir, SWAT

Modelling potential impacts of Climate Change on hydrology of a small urban catchment on the North of Spain

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Abstract

Over the last decades, Climate Change assessment has been an issue of growing concern. Scientific community and political agencies have been searching for better understanding of this situation to manage social actuations. Climate has direct effect on water balance and water has a strong affection on human living. Therefore, there is a need on forecasting water balance evolution on Climate Change scenarios.

Soil Water Assessment Tool (SWAT) has been widely used on modelling potential risks of Climate Change. In this study, SWAT model is used to assess these impacts on hydrology and its components, the case of Deba, a small urban catchment on the North of Spain (Gipuzkoa).

Deba River urban catchment covers an area of 451km² and has been previously studied regarding sediment pollution and water quality. It has been stated as the most polluted catchment on Gipuzkoa due to industrial activities and urban wastewaters. This study is an evaluation of the water balance on this catchment. The first step performed in this study was a calibration using data from three gauging stations located within the catchment (1998-2004). Statistical analysis, r² and Nash-Stutcliffe, were used to assess the goodness of the simulations. Daily calibration, Manual Calibration and SWAT-CUP, resulted on over 0.8 values for r² and Nash-Stutcliffe. Period (2005-2015) served as validation for the calibration performed.

Global Circulation Models were scaled to regional areas using Analogues technique. The model chosen to generate this data was the CNRM-CM5 (from the National Centre for Meteorological Research, France). Precipitation and minimum-maximum temperature time series were downloaded from the Spanish Meteorological Agency (AEMET) for the RCP 8.5 scenario from International Panel for Climate Change (IPCC). Bias-correction was performed for the two periods: baseline (1961-2000) and forecast (2006-2100).

Application of the model to these data showed a decrease in rain (13% in autumn), an increase on the Potential Evapotranspiration (10% in winter) and, in consequence, a decrease of discharge on the outlet of the catchment (around 27% in summer). Further discussion will be found on the publication.

Keywords

Climate Change, Hydrology, SWAT, Urban catchment

Assessment of SWAT sediment export and transport prediction in watersheds of different geomorphological and hydroclimatic conditions in Taiwan

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Abstract

Climate change driven extreme rainfall intensity and frequency have increased in Taiwan. Heavy rainfall usually triggers landslides and generates huge amount of erosion from hillside, leading to substantial variation in sediment concentration in rivers. In order to understand the spatiotemporal variation in stream sediment concentration in watersheds of different geomorphological and hydroclimatic conditions, we selected four major watersheds in Taiwan: the Tamsui river basin in northern region, the Zhuoshui river basin in central region, the Gaoping river basin in southern region and the Hualien river basin in eastern region. We used SWAT model to assess the sensitivity analysis and calibration for streamflow, sediment concentration and exports in different watersheds, and to further evaluate the effects of extreme rainfall on sediment export via four different sediment transport methods: the Bagnold equation, the Kodoatie equation, the Molinas & Wu equation, and the Yang sand and gravel equation. Moreover, we adopted the Taiwan Universal Soil Loss Equation (TUSLE) to improve the accuracy of the sediment exports simulation in SWAT. The preliminary results showed that due to climate change greater variation in sediment exports was found in the southern Taiwan and watershed geomorphological and hydroclimatic conditions could restrict the selection of an optimal sediment transport equation in SWAT. By comparing the differences in spatiotemporal variation in stream sediment concentration in watersheds, a set of suitable sediment rating curves, sediment-related SWAT parameters and sediment transport equations could be applicable for future sediment studies in Taiwan.

Keywords

SWAT, TUSLE, sensitivity analysis, sediment transport, model calibration

Assessing the Impact of Regional Climate Models on Hydrology of a Semi-Arid Watershed Using SWAT Model: The Case of the Wadi Tafna (Algeria)

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Abstract

Impacts of climate change on water resources can be exacerbated in regionsalready presenting low water resource levels and frequent droughts and subjected to imbalances between waterdemands and available resources.

At the beginning of the 1970s, the impact of climate change began appearing in northern Africa, as well as in other regions, by an increase in temperature and a decrease in rainfall.

In the study we focus on the impact of climate change on the Tafna basin in northwestern Algeria over a period of 30 years (1981-2012). Our objective is to validate this period of control by comparing regional climate models to observeddata and modelling SWAT in order to study future projections and to better clarify their impacts on water resources. This leads us to conduct a coupled study between the projection of regional climate models on the basin to quantify the flow at the watershed scaleby using the hydrological modelSWAT (Soil and Water Assessment Tools).

The application will conduct to a methodology that will calibrate the SWAT model to study the hydrological regime of the basin usingseries of climatic data from the last 30 years (1981-2011). After validating, we move on to the introduction of regional climate models as data Inputs for the simulation and comparison of the hydrological regime of each climate model with that of the observed data. The validation of this study will allow us to have a better knowledge of the hydrological modelling. The first results show a slight overestimation, on average, of the simulated flow from the regional climate models in relation to the simulated flow from data observed during the summer period as for that of the winter. This study leads us to decide to validate the period of control and to be able to proceed to the future projection taking into account the overestimation.

Keywords

Tafna, SWAT, Regional Climate Models.

Impact of temporal resolution of rainfall inputs on the performance of the SWAT model in Peninsular Spain

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Abstract

Temporal resolution of rainfall plays an important role in determining the hydrological response of river basins. Rainfall temporal variability can be considered one of the most critical elements on the predictive performance of rainfall-runoff models. In this study, a SWAT model has been used for the study of the above-mentioned impacts. Two basins were selected for this study due to their location in two contrasting climatic regions of Peninsular Spain. These were the Ibaizábal river basin, located in the Basque Country, and it is a clear example of oceanic climate, and the Segura river basin, whose semiarid climate is predominant in the southeastern part of Peninsular Spain. From the results obtained in this study, hourly precipitation record for SWAT sub-daily with the Green-Ampt infiltration method was proven to be efficient for streamflow simulation, especially for Mediterranean basins, where rainfall regime is characterized by a high variability and irregularity. In the Segura river basin, model performance obtained using hourly precipitation and applying the Green-Ampt infiltration method has demonstrated to perform better than the model obtained using daily rainfall inputs and applying the curve number method, primarily due to its better capability of simulating peak flows. In the Ibaizábal river basin, model performance is very similar in both cases, but a more realistic value for the most sensitive parameters has been obtained using daily rainfall inputs and applying the curve number method.

Keywords

Daily streamflow, SWAT, hourly rainfall, peninsular Spain

Comparison between SWAT and AnnAGNPS model simulations in a Mediterranean watershed

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Abstract

In this study the simulations generated by two of the most widely used hydrological watershed-scale models, the Annualized Agricultural Non-Point Source (AnnAGNPS) and the Soil and Water Assessment Tool (SWAT), were compared in a Mediterranean watershed, the Carapelle, located in Apulia, Southern Italy.

The input data required, time and effort devoted for input preparation, strength and weakness points of each model, ease of use and limitations, from a user point of view, were evaluated.

Models were calibrated and validated for runoff and sediment load, using a daily measured dataset (from January 2007 to December 2011). Different statistical indices were used to evaluate the models performance. Both models generally showed fair to very good correlation between observed and simulated runoff and sediment load during calibration and validation processes.

To improve the model performances in calibration and validation, the entire dataset was split in two periods, the dry (May to September) and the wet (October to April). For both models, better simulations were obtained during the wet period, with respect to the dry one. This could be due to the greater difficulties in simulating the low flow conditions that characterize Mediterranean temporary rivers during dry periods.

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Keywords

SWAT, AnnAGNPS, Mediterranean Watershed, Water yield, Sediment load

SWAT Modeling of Seasonal Differences in Nitrate Leaching

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Abstract

Irrigation and fertilization are the main inputs for sustainable and fertile agricultural production. However, excessive use of these two inputs cause environmental and economic problems. Various adaptable tools could be used to lessen these risk factors, such as modelling approach. This study was carried out in Akarsu Irrigation District (AID) of southern Turkey (between 36°51'45" and 36°57'35" N latitudes, and 35°24'10" and 35°36'20" E longitudes). AID provides farmers with a wide range of use for all Mediterranean and warm season crops. The district covers an area of 9495 ha (irrigation area), and the hydrological area is 11,308 ha in the Lower Seyhan Plain (LSP), and has been irrigated for over 60 years under conventional irrigation and drainage infrastructures. Since 2006, nitrogen and water budgets of the irrigation area are calculated within the scope of the projects. Spatial and temporal data such as NO₃ concentration, flow rate, general observations like farming habits, fertilizer application dates and amounts, crop yields etc. are also present. In Akarsu, irrigation has been conducted in two different seasons named irrigation season (from the beginning of April, till the end of September) and non- irrigation season (from the beginning of October, till the end of March). In this study, monthly nitrate (N) leaching in the two different seasons are simulated and compared by using a SWAT model to observe the effects of temporal variation on nitrate losses to drainage water. The measured and simulated nitrogen values in drainage water in the mid seasons of irrigation and non-irrigation seasons were higher because of excessive and unused nitrogen fertilizers during wheat sowing and early growth stages as well as the stimulated leaching by heavy irrigation. Therefore, SWAT model and modelling approach could be used in irrigated and fertilized areas to predict N leaching, and to observe the influence and importance of temporal changes and agricultural practices as well.

Keywords

nitrate leaching, semi-arid regions, fertilization, irrigation season

Modelling nitrate in-stream retention using SWAT model and STATISTICAL model at watershed scale: the case of the Garonne watershed (France)

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Abstract

Surface water contamination is currently and for the future, one of the major environmental issues in a context of global changes. Water self-purification is one of the ecosystem services that is still difficult to quantify. Ecosystem services provide benefits and better quality of life for people. Quantifying regulating functions in time and space is a challenge for evaluating regulating services. This is the reason why we decide to develop a methodology based on straightforward parameters, easy to obtain in order to quantify in-stream nitrate uptake as a service indicator. In this study, we focused on nitrate uptake into a stream network and its spatial and temporal variations. Two models are implemented in this study to explore the nitrate uptake dynamics of and its related key factors that can explain the hot spots and the hot moments of the nitrate uptake in the watersheds. The first one is a statistical model of nitrate uptake rate which fits only on head basin and based on in situ measurement of 11 rivers in Europe and it was then applied at the Garonne watershed scale (France). The first step was to define mathematical relationship between hydromorphological parameters and nitrate uptake rate according to data measurements. A multivariate approach identifies three groups of streams according to their hydromorphological characteristics (mainly slope, discharge, Froude number) and equations were created to quantify nitrate uptakes. The second model (Soil and Water Assessment Tool, SWAT), a semi-distributed physical based model, aims to simulate nutrient transfers at the scale of the watershed and into the river network (OUAL2E). Results obtained with the statistical model were compared with the SWAT simulations to validate the uptake rate in the river networks. The two models show a strong relationship between stream hydro-morphological parameters, nitrate concentration and nitrate uptakes. This study quantifies the evolution of this uptake rate through season from 2000 to 2010 in the river network. This study highlights time periods and area where nitrate retention is the more effective in stream network. Nitrate retention is higher during Spring and Summer. With the statistical model, upstream areas have better retention than downstream ones. Whereas nitrate retention modelled with SWAT is linked mainly to flow discharge and morphological characteristics of each reach and increases when the climate is warm and dry.

Keywords

nitrate retention; nitrogen cycle; water quality regulation service; modelling; watershed; river network; SWAT

Hierarchical Calibration of SWAT Model in Paraguaçu Basin River.

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Abstract

The Paraguaçu watershed, located in Bahia State, Brazil, is under the influence of a semi-arid climate, characterized by significant spatial-temporal variation in precipitation regime and land-use cover. In this work we assess the potential of the SWAT model to predicate the hydrologic regime of the Paraguaçu River under different soil uses/land cover and rain scenarios.

Our model application uses the hierarchical scheme calibration proposed by Klemes (1986). The values of statistical coefficients NSE, PBIAS and R² show that the model can be classified as "satisfactory" when predicting the Paraguaçu River flow. When wet and dry periods were considered separately (Differential Split-Sample Test) the NSE, PBIAS and R² values of wet years (2004 to 2006) were 0.63, -13% and 0.85, respectively, and the dry year values (2007 to 2010) were 0.59, 11% and 0.66, respectively.

The SWAT model validation for a watershed with similar land use (Proxy-Catchment Test) can also be classified as "satisfactory" to simulated land use change. Based on the results we can assume that the SWAT model can be used in further studies to simulate land use and climate change scenarios.

Keywords

Hydrologic process, semiarid, Watershed Paraguaçu River, Calibration, SWAT.

Modelling flash floods at hourly time-step: relevance of the SWAT model evaluated with the MARINE model

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Abstract

Flash floods are natural phenomena with environmental, social and economic impacts, sometimes leading to heavy casualties. To date, few numerical models are able to simulate hydrological processes at catchment scale at a reasonable time scale to describe flash events with accurate details. Considering a ~800 km² Mediterranean river coastal basin (southwestern France) as a case-study, the objectives of the present study were (1) to highlight the key processes involved in the simulation of flash floods by both the time-continuous lumped SWAT model and by the event-based fully distributed MARINE model, (2) to compare river discharge and soil water content before and after a number of selected flood events simulated by the two models, and (3) to provide guidelines about the use of SWAT hourly module in large basins. Using SWAT, we compared the performances of two output time-steps (daily and hourly) and we compared two sub-basin delineation schemes (15 000 ha and 1 000 ha minimal drainage area). We showed there was no benefit of decreasing the size of the minimal drainage area when delineating sub-basins in SWAT. We then compared the discharges simulated at flood-event scale by SWAT and MARINE and showed that both models were equally able to reproduce peak discharge although the performances of both models were limited by rainfall and soil data, and thus by the soil water content at the beginning of the floods. Hence, the SWAT model appears as a reliable modelling tool to predict discharge, including sub-daily peak discharge, over long periods of time in large flash flood-prone basins.

Keywords

Flash storm; Flood event; Sub-daily simulation; Peak discharge; Runoff; Mediterranean watershed

Using a SWAT and a GIS coupled approach to assess the role of Amazonian wetlands in carbon and nitrogen biogeochemical cycles.

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Abstract

The amount of greenhouse gases released to the atmosphere by human industries and agriculture, such as carbon dioxide (CO₂) and nitrous oxide (N₂O), has been constantly increasing for the last decades. Nevertheless, wetlands ecosystems provide an optimum natural environment for carbon sequestration and nitrogen uptake processing. Wetlands are ecotones, transition areas between land and aquatic environment which supply various ecosystem services: water purification, flood control, shoreline stability, etc. Amazonian wetlands are subjected to seasonally flooding events due to water level changes of the river which trigger off denitrification processes under anaerobic conditions. The main objective was to develop a methodology which makes consistent both satellite observations, in-situ measurements and hydrological modelling outputs of the Amazon basin to identify and quantify the peculiar role of riparian wetlands to carbon and nitrogen regulation. In this study we focus on the role of Amazonian wetlands in carbon and nitrogen cycles and more particularly on the part of denitrification in CO₂/N₂O emissions during flooding events. We determined the spatial and temporal distribution of water surface extent with the Soil Moisture and Ocean Salinity (SMOS) mission within the watershed. Meanwhile we built and calibrated an integrative hydrological model of the Amazon using the Soil and Water Assessment Tool (SWAT) programme. Denitrification and CO₂ outgassing processes were implemented considering the first 30 cm of inundated areas as active layers. We aim to compare inundation data estimated by SWAT with the ones extracted from SMOS in order to better assess the impact of the flood pulse on biogeochemical processes and to quantify the amount of CO_2/N_2O outgassed due to denitrification. It is likely that we will observe that denitrification play a key role in CO₂/N₂O outgassing from wetlands and may be considered as a significant source of carbon. The method described in this study can be transposed to other large watersheds. Moreover, it constitutes a basic methodology for water resource quality management which can also be applied to develop strategies to reduce nitrate in oversaturated agricultural soils.

Keywords

wetland, SWAT, SMOS, Amazon watershed, carbon and nitrogen cycles, remote-sensing, modelling.

SWATpasteR: Parallel SWAT execution and sensitivity testing in R

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Abstract

Sensitivity analysis, uncertainty assessment and model calibration/validation are essential steps in the modeling work flow with any hydrological model application. For the Soil and Water Assessment Tool (SWAT, Arnold et al., 1998), SWAT-CUP has been established as the standard software for calibration and sensitivity analysis of SWAT projects. Although, SWAT-CUP provides a large range of functionalities for a standard modeling workflow, it is often not applicable to new methods and work flows.

The script language R is gaining in popularity in the natural sciences due to its open source philosophy and a large community that generated more than 10000 R packages until now. Recently, many SWAT users employ R to modify their SWAT projects, or to analyze model outputs. Consequently, we decided that an R package covering the execution of SWAT and the analysis of model outputs could be an essential contribution to the SWAT community.

SWATpasteR is an R package that provides intuitive work flows for parameter sampling, SWAT model execution and the analysis and visualization of model results involving strategies for calibration/validation and Global Sensitivity Analysis of input factors. Parameter sampling strategies such as random and quasi-random sampling, but also sampling designs for Sobol sensitivity analysis (Sobol, 1990) and the recently developed STAR sampling (Razavi and Gupta, 2016) were implemented so far. Sensitivity analysis and model calibration typically require large numbers of model runs and computation time is a critical factor. Hence, we implemented parallel processing for the SWAT model execution in SWATpasteR. To make the application of the package rather flexible we provide an intuitive selection of output variables and derivatives for all executed model runs, as well as the ability to store the results in a well structured way for further processing. To date, the Sobol and the VARS approaches (Razavi and Gupta, 2016) are implemented as Global Sensitivity Analysis methods including routines to visualize the ranking of input factor sensitivities, and the resulting time series of any output variables.

Albeit not published yet, SWATpasteR will be soon made accessible to a broad community of SWAT users. The work flows provided with the package were already tested in a handful of projects. The functionality of the package is so far very much tailored to our individual requirements. The open accessibility of the package and the included code should however encourage many users to implement routines useful for their individual projects and could consequently benefit other users by a growing variety of functionality of the R package.

Keywords

Rstats, R package, parallel processing, sensitivity analysis

SWATfarmR: A simple rule-based scheduling of management operations for SWAT

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Abstract

The possibilities of applying the Soil and Water Assessment Tool (SWAT, Arnold et al., 1998) to environmental questions are diverse. Consequently, SWAT is a widely accepted modeling tool to examine interdisciplinary questions at the watershed scale. However, the models' flexibility in its application comes with a high demand of input data. For instance, examining the nutrient cycles (N and P) with SWAT strongly relies on an adequate representation of the farming activities in a watershed. This typically requires land use and crop data with a high spatial and thematic resolution, as well as detailed information on crop management practices. Most SWAT applications however, lack such detailed data.

In its current form, the SWAT model offers the option to trigger management operations either by employing the Potential Heat Units (PHU) concept or by setting fixed dates for individual operations. Yet both methods fail to emulate actual farming schemes. The fixed date approach implies that farmers set specific operations simultaneously in the entire watershed . Apart from being unrealistic, this is crucial when simultaneous fertilizer application coincides with heavy rainfall events causing strong peaks in the modeled nutrient loads. The PHU concept achieves a certain temporal stratification of the management operations based on daily temperature input data. It is however highly sensitive to inter-annual variability of temperature and consequently can result in unrealistic dates for the triggered field management operations.

SWATfarmR tries to overcome these issues by setting fixed operation dates that are temporally distributed between the Hydrological Response Units (HRU) for the same land use and that vary between the simulated years. Applying simple rules, while requiring only little additional input data SWATfarmR enables the modeler to control the conditions when management operations should be triggered. The key input is a table that provides date ranges for operations to be scheduled for each crop in a specific model setup. From these date ranges, SWATfarmR randomly selects dates for each individual HRU to achieve temporal stratification of an operation. Employing precipitation and temperature data, SWATfarmR can exclude days with strong rainfall or days with potentially high soil moisture and can trigger operations earlier or later in a specific year, i.e. when a growing season is unusually warm or cold. These simple rules try to emulate farmers' decisions to a certain extent but also consider climate change, where longer cropping seasons are likely to occur.

SWATfarmR is available (albeit not published yet) as an intuitively applicable R package that enables a broad community of SWAT users to easily implement more realistic farming practices and climatic conditions in the management operations of their SWAT projects. The outlined framework of the package will be open for extending and adapting the proposed concepts and rules. Functionalities such as crop rotation, or gradual land use change are in development. While we applied SWATfarmR to several case studies, the validity of the implemented rules and the resulting operation schedules was not yet shown.

Keywords

SWAT, Rstats, R package, management practices

Forecast of Instantaneous Peak Flow using SWAT and ANN

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Abstract

Flash floods are one of the most significant natural hazards in Europe, especially in Mediterranean countries. In recent years, flash floods have caused many economic losses and loss of life throughout Peninsular Spain. Estimation of the frequency and magnitude of the instantaneous peak flow (IPF) is crucial for the design of hydraulic structures and floodplain management. As happens in many countries around the world, Spanish basin management agencies record data relating to mean daily flow (MDF), while the availability of IPF time series is less frequent. The application of techniques that reduce uncertainties associated with IPF forecasts is needed regarding the damage flash floods imply. The first objective of this study was to assess the performance and applicability of the Soil and Water Assessment Tool (SWAT) model for prediction of MDF in the Ladra river basin. The calibration and uncertainty of the SWAT model were performed with Sequential Uncertainty Fitting version 2 (SUFI-2). To increase the sensitivity to high flows, a modified Nash–Sutcliffe efficiency factor has been used as objective function for model calibration. The second objective was to compare empirical methods and artificial neural networks (ANN) to estimate the IPF based on maximum mean daily flow (MMDF). The results show that (1) the SWAT model performed with other empirical methods, and (3) the artificial neural network (ANN) has showed a superior ability for predicting IPF compared with any empirical formula.

Acknowledgments: The authors gratefully acknowledge support from the UCAM through the project "PMAFI/06/14". This research was also partially supported by the GESINHIMPADAPT project (CGL2013-48424-C2-2-R) with Spanish MINECO funds.

Keywords

SWAT, artificial neural network, hydraulic design, instantaneous peak flow, Ladra river basin

Identifying critical source areas for the control of nonpoint source pollution using the SWAT model

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Abstract

The control of non-point sources pollution is very difficult, because it is not consistent on temporal and spatial distributions. So the identification of priority management areas (PMAs) at the large-basin scale is facing the same difficulties. In this study, a decision support system (DSS) for figure out the critical source areas, or PMAs from a certain view, is designed based on the Soil and Water Assessment Tool (SWAT). The DSS can take the output file of SWAT, simulated monthly for many years, as input. Calculate the contributions of each sub-basin to given sensitive areas' water quality. Furthermore, identify the sub-basin which contribute the most to water quality deterioration when the sensitive areas can't satisfy the water quality standard. Both watershed and river processes are being considered. According to the result, focusing on several sensitive areas makes it easier to reach the goal of water function; the river processes are vital for water quality degradation in the river network and significantly influenced the final PMA map; the monthly-scale simulation and covering many years have obvious meaning to keep the water quality of sensitive areas reach the standard.

Keywords

Nonpoint source pollution; priority management areas; Soil and Water Assessment Tool; decision support system

SWAT applications for transboundary river management between EU, Ukraine and Russian Federation

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Abstract

Water cycle in the basin is the main factor of water budget, sediment and nutrient loads. Transboundary water problems are becoming urgent because of significant differences in national legislation and water management. International cooperation in water management needs compatible results on evaluating catchment use consequences for water budget and chemistry. Common type of complex results can be obtained using the same methods for different catchments. Modern international water resource management should be based on detailed knowledge about water regime as the main factor of matter flows.

Meteorological and hydrological conditions as well as site characteristics are the main factors that determine the water and matter flows in river basins. In transboundary basins the handling of the quantitative and qualitative aspects of the water flows is a complex task because of significant differences in data quantity, quality and types of data source.

The European Union,Ukraine and Russia share various river basins that cross one or more international borders such as Western Bug, Desna andWestern Dvina (Daugava). Water quality problems that need to be dealt with in a transboundary setting are the connective element of these basins. One of the ways to provide transnational system analysis and dialogue is Integrated Water Resources Management (IWRM). Within the project Management of Transboundary Rivers (MANTRA-Rivers), which is funded by the Volkswagen Foundation, Scholars and Scientists from Ukraine, Russia and Germany work together to promote trilateral dialogue and cooperation and investigate the scientific basis for an IWRM conceptualization in the three model river basins.

In this contribution we focus on Western Dvina (Daugava) catchment. The basinis situated in Russian Federation, Belarus and Latvia (and small parts in Lithuania, Estonia). Russian part of basin has extremely weak hydrological and meteorological gauging stations network. ArcSWAT input data is based on different sources of land cover (GlobCover, OpenStreetMap, remote sensing data), soil characteristics and distribution (National soil registry combined with FAO and HWSDcharacteristics), relief (SRTM), meteodata (observations, NCEP CFSR and ERA-Interim data combination). The comparison of reanalysis data with observed meteorological characteristics reveals a lot of uncertainties (especially in precipitation amount) and gaps (wind speed and solar radiation) as the SWAT input data. Russian soil data is also specific and is not directly compatible to global databases and needs to adapt to SWAT database. Calibration using SUFI2 method was performed using SWAT CUP. First results of hydrological modeling of Western Dvina (Daugava) are presented.

Keywords

SWAT, Transboundary catchments, Western Dvina (Daugava), Water regime, Hydrology, Calibration, ERA-Interim, NCEP CFSR

Joint use of snow and discharge time series for SWAT model calibration

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Abstract

Snow is a crucial hydrological component that highly affects streamflow dynamics in alpine catchments. A realistic representation of snow dynamics is hence fundamental for a reliable description of the hydrological cycle in this environment. The Soil and Water Assessment Tool (SWAT) model has been applied in the hydrological modeling of alpine catchments worldwide. However, snow measurements have been rarely used for model calibration and the snow parameters were estimated based on streamflow records. This may lead to streamflow predictions with an incorrect snow behavior. This work highlights the importance of considering snow measurements in the calibration of the SWAT model and compares various calibration methodologies. In particular, snow water equivalent time series derived from snow depth observations of snow monitoring stations were utilized along with discharge to calibrate the model. Comparing model results obtained calibrating the model using discharge data only and discharge data along with snow water equivalent data, we show that the latter approach allows to improve the reliability of model predictions. As a result, uncertainty of streamflow simulations propagated from snow components were reduced. This study offers to the wide SWAT user community an effective approach to improve streamflow predictions in alpine catchments.

Keywords

SWE; Alpine catchment; SWAT model; Snow measurements, Snow parameter variability

Using SWAT in a coupled modeling framework for the development of renewable gases in the heating market

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Abstract

About 50 % of the heat supply in the Federal Republic of Germany is based on the use of fossil natural gas. In order to significantly increase the share of renewable gas in the heating market, the potential to replace fossil gas must be estimated under the constraint to avoid adverse impacts on the environment. One scope of the project "SustainableGAS" is to assess the impact of an increased cultivation of energy crops on water, nutrient and energy fluxes within hydrological catchments. We apply the eco-hydrological model SWAT in a novel model coupling concept with an agent-based model, to assess such mechanisms in a bidirectional manner. The outputs of the SWAT model are employed as drivers for the agent-based model at predefined (annual) time steps under various development scenarios; taking into account the impacts on ecosystem services, agents (e.g. farmers, policy makers) will take decisions on environmental regulations and agricultural practice, which will be used for an adapted parameterization of the SWAT model for the next model time step. The scenarios are analyzed to determine preferred pathways to support a sustainable transition of energy systems.

The poster shows the project idea and a general overview of the coupling of SWAT with the agent based model.

The project "SustainableGAS" is financed by the German Federal Ministry for Economic Affairs and Energy.

Keywords

coupling SWAT with an agent-based model, energy systems transition, environment

Modelling self-purification in rivers from hydro-morphological units to watershed scale

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Abstract

Due to a population boom, industrial and energy revolution, and increase in agricultural cultivation, mankind is facing complex environmental issues of aquatic ecosystems. In addition, climate change adds uncertainties to water supplies and irrigation, which will in turn aggravate uncertainties of water demands. To ameliorate this trend, it requires that we gain a better understanding of the interactions between the disturbances induced by human and their effects on the aquatic systems. Among these interactions, evolution of ecological services involved in regulation of water quantity and quality is very difficult to characterize and to predict. Hydrological models are important tools to assess the interactions between different processes. Soil and Water Assessment Tool (SWAT) is a process-based hydrological model, which is widely used to simulate the quality and quantity of surface and ground water and to predict the environmental impact of landuse, land management practices, and climate change. However, few studies are involved in quantifying the ecological functions linked to selfpurification of water at the scale of a watershed. Many studies investigated the specific role of hydro-morphology on retention processes, but it is still difficult to quantify and determine the hot spots at the scale of a watershed. In this study, the objective is to investigate the spatial and temporal process of self-purification of water at a large scale. We will present here the general methodology of the study. First, we will set up and calibrate a model, focusing on the hydrologic and nitrogen cycling, at the scale of hydro-morphological unit (rivers). After finding out the most efficient unit and controlling factors involved in self-purification, we will improve the model by integrating the different efficient zones in self-purification at the scale of watershed. Once the methodology is validated, the model will be applied to other large watersheds in Europe. The results will provide information for planning sustainable use of water resources to meet various demands.

Keywords

self-purification, river, watershed, hydrologic cycling, nitrogen retention.

Evaluation of climate change and land use impact on suspended sediment production and its quality in different catchments of Poland

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Abstract

The threats of climate change are becoming more and more real, and its effects are beginning becoming apparent in a global, and local scale. Unusual, previously unknown, phenomena such as heat waves, droughts, violent thunderstorms or flood events intensify. Climate change models, in addition to an increase of air temperature, indicate also a change in the precipitation pattern. During winter we will experience strong rainfalls, while during summer there will be no precipitation and extreme droughts. These changes will lead to processes occurring in river catchments, such as erosion which is responsible for soil particle washout to the rivers. Since, these particles have strong sorption properties, numerous pollutants are likely to enter waters, which may also significantly affect quality of water in rivers. So, there is no doubt that there is a danger of increased river pollution due to climate change. Analyzing the problem of erosion in the context of climate change, we cannot forget about the land use in of catchment area. The way of land use, especially agricultural, can both contribute to and increase and decrease of erosion process. It depends mostly on the type of crops or agrotechnical techniques. Working on a scientific solution of this problem, the Authors have asked three basic questions: i) Do projected patterns of climate change in Poland will affect quantity and quality of suspended sediment released from catchments and transported in rivers? ii) Can regional variation pattern of climate change in Poland be used as a base to select areas of higher vulnerability for erosion and suspended sediment transport in rivers? iii) What impact on the quantity and quality of the suspended sediment can pose a modification of catchment management? The main goal is to find answers for these questions. In order to achieve the intended goal, will combine the capabilities of mathematical modeling and field and laboratory research. The designated study areas are located in three regions of Poland that differ in terms of soil types, hydrology and climate. They also differ in terms of land use, vegetation type, and degree of human impact on the environment. The selected catchments are as follow: i) upper Raba River (from the sources to the Dobczyce Reservoir) - representing the submountain river in the Western Carpathians, characterized by strong erosion; ii) Bystrzyca Lubelska - located in the Lublin Upland region, representing loess valley at the most agriculturally developed area of Poland; and iii) Słupia River - which catchment forms part of the Pomerania, where clays and loams are abundant, and there is also high amount of precipitation. To achieve new knowledge about climate change and its impact on the catchment ecosystem the Authors will use the SWAT model to determine the amount of particles entering surface waters, as well as the amount of suspended matter carried along with water masses. However, in order to answer also the questions about suspended matter the fingerprinting method will be integrated with the SWAT model, to determine precisely which pollutants are transported along with the river. The mathematical model will also allow predicting the impact of both, climate change and land use and management of the catchment area on water balance and degree of water pollution.

Keywords

Climate change, erosion, suspended sediment

Determination of the CN parameter in the forest catchment area on the example of Łutownia river in Bialowieza Primeval Forest

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Abstract

The simple SCS-CN method is used to calculate the effective precipitation that is used in modeling hydrological phenomena. It has been developed mainly for agricultural land, although after some modification it can also be applied to forest areas. Its purpose is to make the precipitation depend on the type of land cover, soil type and moisture content. All of these factors include the non-dimensional parameter CN. The source of the land acquisition data is the Corine Land Cover (CLC) database developed within the framework of the European Environment Agency for the European Union. In the analysis, the land cover was modified, taking into account the stand characteristic called the tree level. This resulted in a new classification of forest cover. Analyzes using new classes were made for the Łutownia river basin in the Bialowieza Primeval Forest. To verify the accuracy of the CN value estimate, the flood hydrograph was checked. For this purpose, the one flood hydrograph with a 24 hour time step was used. To transform effective rainfall into direct runoff, the SCS-UH method was used.

Keywords

SCS-CN method
Application of the SWAT model to investigate hydrology, sediment and nitrate flux towards the Mediterranean Sea: case of the North Africa catchments

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Abstract

Water in North-West of Africa is an increasingly valuable resource due to high competition between agriculture, industry and drinking water supply, accentuated by frequent drought conditions in a semi-arid climate. For a few decades, the demographic explosion, the development of agriculture, industry, and the building of water infrastructures (dams) have modified the water, sediment fluxes and the biogeochemical cycle of nitrogen towards an increased production of nitrates in waters. The objectives of this study are to propose a modelling approach to quantify the contribution of the North Africa catchment coastal watershed to the flux of sediments and nitrates into the Mediterranean Sea. The modelling approach is made to identify and to understand (1) the climatic controlling factors of the sediments and nitrates exportations, and (2) the role of dams in the retention of sediment and nitrates, integrating the impact of current agricultural practices on surface water. This approach will help us to quantify the contribution of the watershed to the eutrophication of the Mediterranean Sea while predicting the load of nitrates carried down to the marine waters. To do so, we applied the Soil and Water Assessment Tool (SWAT) which has been widely used to assess hydrology in various catchments, on biggest five coastal Rivers of North Africa, Moulouya(55 860 km²), Tafna (7200 km²), Chlef (44 694 km²) Oued el Kebir (8 824 km²) and Medjerda (23 213 km²). Simulation was performed monthly from January 2000 to December 2013 (excluding a 3 year warm up from 2000 to 2003). The results obtained are very encouraging. SWAT makes it possible to correctly represent the dynamics of water, sediment and nitrate flux in the North Africa watersheds. Rivers in these region carries an amount of sediments between 22 to 399 Ton yr⁻¹ and Oued el Kebir River contribute with the biggest quantity (54%), while nitrates fluxes vary from 105 to 664 Ton yr^{-1} to the sea and Medjerda River contribute with the biggest quantity (40%). The swat simulation shows us also that the North Africa dams stocked a large amount of sediment (98%) and nitrates (39%) transported by the Rivers to the Marine water.

Keywords

water scarcity, sediment flux, Nitrates flux, Swat, North Africa catchment, Mediterranean Sea.

The influence of the DEM resolution on the LS factor and SWAT estimates of soil erosion on the example of upland loess watershed in Poland.

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Abstract

The paper presents results of an assessment targeting the influence of DEM resolution on the calculation of LS factor as a major topographical index shaping erosion intensity on the example of Bystra catchment, located on loess soils of Naleczow Plateu in Eastern Poland.

The aim of the study is to estimate the errors in water soil erosion estimates when modelling large areas, characterized with varying terrain relief, with small resolution DEM datasets.

The influence of spatial resolution for NMT on the modeling result using LS was analyzed and evaluated. The analysis was conducted for Numeric Terrain Models with a spatial resolution of 1 m, 5 m, 10 m, 30 m, 90 m.

The resolution of the generated NMT has a direct effect on the modeling result. The difference in results between spatial resolution models 30 m, 90 m and 1 m, 5 m, 10 m is remarkable. The preferred NMT used for LS modeling will be models with spatial resolutions of 1, 5 and 10 meters.

Keywords

LS factor, soil erosion, spatial resolution

Improved understanding of the impacts of hydroclimate, land use and agricultural management practices on nitrate concentration dynamics using SWAT

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Abstract

The relationship between nitrate concentrations and stream discharge is complex. Recent high-resolution temporal nitrate concentration and streamflow measurements have allowed insights into concentration-discharge dynamics to gain a better process understanding of nitrogen transport in catchments.

For example, in a chemodynamic stream, the nitrate loads being transported to the stream can either be "source limited" or "transport limited". When nitrate is source limited, a dilution in the nitrate concentrations takes place with increasing stream flow volume. This effect can be measured with high resolution nitrate concentration sampling data and is typically observed through hysteresis loops being clockwise. The accretion effect, on the other hand, is due to transport limited nitrate, and typically shows an anticlockwise hysteresis loop, whereby the nitrate concentration increases with discharge. These concentration-discharge dynamics are valuable to understand, to predict when influxes of nitrate will enter the stream.

Unfortunately, in most catchments such high temporal water quality measurements are lacking, and thus, it is not possible to know if dilution or accretion occurs with changing stream flow events. We set out to determine if an eco-hydrological model, such as SWAT (Arnold et al., 1998), is able to provide insights into the nutrient concentration dynamics that occur after rainfall events and during different times of the year. The specific objective was to statistically assess whether the SWAT model can capture the dilution and accretion dynamics of nitrate concentration measured at high temporal resolution due to the influences of hydroclimatic patterns, land use and agricultural management practices in the catchment.

We applied the SWAT model to the Raab catchment, in Austria, using a DEM of 10 m, detailed land use and crop management statistics at the municipality level, and soil information obtained from SoilGrids. The years 2009-2012 were analyzed at the daily time step to determine hydroclimatic influences, land use and agricultural management practices impacts on nitrate dynamics at two gauges (Takern II and Neumarkt an der Raab).

The SWAT simulated nitrate concentrations at the two gauges were compared to high resolution time series of water samples measured for nitrate concentrations obtained at 5 minute or at 60 minute intervals, as well as to discharge at 30 minute and precipitation at 15 minute time steps, for the same time period. The concentration-discharge relationships were examined to provide explanatory variables for the relationships. Furthermore, a statistical comparison of the measured nitrate concentrations to the SWAT simulated nitrate concentrations in the Raab was undertaken to characterize the nitrate transport dynamics and identify periods of high leaching risk in the catchment.

Keywords

nitrate dynamics, leaching risk, high resolution sampling, chemodynamic.

SWAT Model Application for Simulating Nutrient Emission from Small Agricultural Catchment in the Desna River Basin (Ukraine)

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Abstract

The signing of the Association Agreement with the EU initiated the implementation of WFD and associated directives standards in the field of aquatic ecosystem management. Among other things this includes the assessment of nutrient pollution, identification of vulnerable areas and prevention of a water body eutrophication.

The MANTRA-Rivers project is financed at the initiative of the Volkswagen Foundation aimed at the joint management of cross-boundary rivers. The Desna river basin is shared by Ukraine and Russian Federation and substantially contaminated by nutrients. It has rather a poor ecological status due to water quality problems.

The SWAT model was applied for a small Holovesnya River Catchment (area 30.4 km²), the first order tributary of the Desna river and calibrated for a hydrology and nutrient transport. This basin is representative for a mixed forest physiographic zone. Because of its location on the territory of the water balance station it has a rich hydrological and meteorological data coverage.

The model was calibrated within SWAT-CUP at a daily time step for the years of stable economy (1985–1986) and the years of economic contraction (2007–2009). The validation was done for years 1987–1988 and 2010–2012 respectively.

The obtained results were good for a stream flow (NS, $R^2 > 0.6$, PBIAS < 4%) and acceptable for nitrogen and phosphorus loads (NS > 0.6, RSR < 0.6, PBIAS < 43%). The flow rate of nitrate was 39 kg/km²×year for years 1985–1986 and 6.8 kg/km²×year for years 2007–2009. The flow rate of mineral phosphorus was 16 kg/km² × year for years 1985–1986 and 1.5 kg/km² × year for years 2007–2009.

Some agricultural practices were tested too. The dependence between fertilizing (amount, separate application) and nutrient yields were evaluated to provide the recommendations for an agricultural management. The increase of the fertilizer amounts results in the reduction of its efficiency. The separate application of fertilizers leads to the nitrate load reduction by 66%.

Keywords

Nitrogen, Phosphorus, SWAT, Fertilizer, Eutrophication

Modeling the Projected Impact of Climate Change on Boukan Dam Inflow and Water Availability in the Zarrine River Basin of Iran

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Abstract

Climate variability and change is projected to impose profound changes globally in hydrologic cycle and water quantity and even quality resulting in freshwater crisis, floods and droughts especially in arid and semiarid areas. In addition, the future water stresses are likely to be exacerbated by population growth and agricultural developments. In addition, NASA satellites showed alarming freshwater losses in the large parts of the Middle East region, especially western Iran, during the past decade. Thus there are enough evidences that the water resources in the region are strongly vulnerable and adversely affected by climate change. Reservoir dams are the most important water resources infra-structure in Iran used for electric power generation as well as for storage for water for consumption. The operating policies are dependent on the dam inflows. To improve future water management policies, the impact of climate change on available water resources should be investigated as a prerequisite, by assessing the hydrological response to changing climate in a river basin scale. In this study water balance and streamflow changes concerning reservoir dam's inflow based on a semi-distributed rainfall- runoff model are simulated under various climatic weather scenarios, predicted from GCM projections of precipitation and temperature downscaled with statistical methods, Quantile Mapping and SDSM. The case study is the Boukan dam in the Zarrine River Basin, which the river has been pointed out as the main source of the Lake Urmia.

Keywords

Dam inflow prediction, SWAT, Statistical Downscaling, Water balance, Quantile Mapping, SDSM

An integrated MODSIM- PSO Model for optimal Multi-Crop Planning in the agricultural Areas of the Karkheh River Basin, Iran, under the Impacts of Climate Change

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Abstract

The Karkheh River Basin (KRB) located in the arid southwest of Iran is a water-stressed region, with its existing water resources under high pressure to meet the growing demands. This vulnerability may be further exacerbated by ongoing climate change in the region which will exert an additional layer of uncertainty on the existing water resources there.

To quantify the impact of different climate scenarios on water discharge in the KRB, a hydrological model (SWAT) was built up and calibrated by means of the SWAT-CUP (SWAT Calibration and Uncertainty Programs) which provides ranges of climatic and hydrological calibration parameters, based on the 95% prediction uncertainty band (95PPU) calculated from the cumulative distribution function obtained through Latin hypercube sampling of the output objective function (observed streamflow).

The calibrated SWAT-model is then used to predict the discharge of rivers in the KRB for several future climate scenarios using predictors for daily precipitation and daily minimum and maximum temperatures as input drivers of the model. To this end we used the most recent climate change projections generated for CMIP5 project of the IPCC report which uses the new Representative Concentration Pathways (RCPs) based on how much more energy is trapped by greenhouse gases in 2100. The medium stabilization scenario RCP4.5 (~CO₂- concentrations of 650ppm by year 2100) and the very high emission scenario RCP8.5 (~CO₂- concentrations of 1350 ppm) from the HadGEM2-ES coupled atmosphere-ocean climate model are selected for climate predictions for the near-future-(2038-2060) and the far-future (2078-2100) time period. Downscaling of the future climate predictors is done by an updated quantile mapping bias correction algorithm on climate data for the 1982-2004 historical reference period.

After SWAT-prediction of the future streamflow and other hydrological components in the KRB, a simulationoptimization model is developed to maximize the annual benefits of a set of multi-crop irrigation areas in a reservoir-irrigation system for the historical and the near future prediction periods - because of too many inevitable uncertainties in the projected land use changes, inflation and population growth, the far-future prediction period was not analyzed -. To that avail the coupled MOSDIM river basin Decision Support System (MODSIM-DSS) and PSO (particle swarm optimization) algorithm is used. While MODSIM is simulating the water allocation between different water users (agricultural, environmental, municipal and industrial), PSO tries to find the best combination of agricultural lands under cultivation to maximize the annual benefits, considering all constrains.

The results of the application of the MODSIM/PSO-model to the KRB indicate that compared with total annual benefits of 94.24 MUS\$ for all multi-crop areas for the historical period, there is a slight decrease to 88.33 MUS\$ for scenario RCP4.5, and a minor reduction to 72.07 MUS\$ for the extreme scenario RCP8.5 in the near future 2038-2060 prediction period. Corresponding simulations and optimizations for the more benevolent scenario RCP6.0 (CO₂- concentrations of 850 ppm) are under way at present and results of them will also be presented.

Keywords

SWAT, SAWT-CUP, MODSIM, PSO

Assessing the impact of climate variability and human activities on the drawdown of Urmia Lake in Iran

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Abstract

The drawdown trend of the water level in Urmia Lake (LU) poses a serious problem for northwestern Iran and huge national and international efforts are going on for the restoration of lake. Various reasons have been stated as the major causes of this predicament, including climate variability and human. Thus, it is crucial to evaluative and distinguished their impacts, which provide a scientific basis for the restoration measures and indicating their priorities. This subject constructs objective of this paper, in which SWAT model has been modified to address the distinctive processes take place in the basin. One the important processes was to simulate the lake bed itself. The LU bed area is about 6200 km² and its water body reaches to less than 2000 km². So, the interaction of the dry and wet parts requires especial simulations that are added in the model, so called SWAT-LU. Furthermore to assess the impact of climate variability; the time series of rainfall and temperature were detrended. Also for the human activities, two land use maps for 1987 and 2007 were prepared using the Landsat images. Finally, the SWAT-LU was executed for 3 scenarios including: 1) the recorded climate data and land use updating (1987 to 2007), 2) recorded climate data and the 1987 land use fixed, 3) detrended climate data and land use updating. The results showed that both climate variability and anthropogenic changes have had significant role on the current status of LU, which are %43 and %49, respectively (the rest belongs to the interaction of these drivers). Of course after 2000, the rates are changed and become %50 and %42, respectively.

Keywords

climate variability, human activities, Urmia Lake, Iran, SWAT-LU

Climate Change effects on the hydrological regime in the Ladra River Basin (NW Spain)

Abstract

Climate change is likely to alter river flow regimes significantly and, as a consequence, may pose a serious threat to river ecosystems. The quantity of water required to maintain a river ecosystem in its desired state is of particular importance in areas of high ecological value. Water-dependent ecosystems are exposed to the risk of climate change through altered precipitation and evaporation. The objective of this study was to calibrate and validate, on a daily basis, a headwater basin of the Ladra River Basin, Northwest Spain, to assess the potential alterations in the hydrological regime under future climate change scenarios. The study area was declared a site of community importance (SCI) in 2004, and it is part of the European ecological network Natura 2000 due to its high ecological value. Furthermore, this basin was declared a biosphere reserve by UNESCO in 2002. For this purpose, climate data sets simulated by RCA4—a regional climate model—nested in the global climate model CNRM-CM5 considering the RCP 4.5 and 8.5 scenarios, were downloaded from the Euro-CORDEX initiative and forced through the SWAT model. The simulations were carried out for the long term (2071–2100) and compared to the simulation of the baseline period (1971–2000). Bias correction was performed using the distribution mapping approach. To evaluate the effects on the hydrological regime, the streamflow output from these simulations was input into the Indicators of Hydrologic Alteration in RIverS (IAHRIS) software, which calculated multiple hydrologic indices compared back to a baseline scenario. The basic flow method (BFM) has been applied as well for the evaluation of low flows. The results showed an increase in the maximum (1.8°C and 3.8°C) and minimum (1.5°C and 3.2°C) temperatures and a decrease in the precipitation (8.0 and 11.9%) for both scenarios (RCP 4.5 and 8.5). The results led to a significant reduction of the streamflow (up to 32.3%) and an important alteration in the drought duration and seasonality. These results underscore the need to put in place appropriate adaptation measures to mitigate these impacts.

Keywords

Climate change, SWAT, IAHRIS, Basic Flow Method, Ladra river basin

Modelling streamflow to set an environmental flow

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Abstract

In Mediterrenean Region, although most of the rivers has an intermittent character, diversions and dams are quite common due to water scarcity and to the competing water use requests. For temporary rivers, the implementation of the Environmental Flow (EF) may be a long and difficult process that has to be built with the stakeholder participation to solve existing problems and include evaluations of alternative scenarios of flow regimes. Hydrologists and river ecologists can contribute to the EF assessment providing information and knowledge and evaluating river evolution under various conditions.

Mediterranean rivers are characterized by highly variable hydrological regimes and often by severe limitation of streamflow data, which are fundamental for describing hydrological regime. In these cases, hydrological models at daily time step must be used to simulate streamflow and alternative scenarios of water release from reservoirs. However, often the extreme low flow conditions could be difficult to be adequately simulated and modelers have to pay particular attention in this task.

In the present work we present the results of a study aiming at supporting the EF assessment in the Celone river basin (Italy) where a dam was built in the middle course of the river that has changed significantly its natural flow regime. The SWAT model has been applied to estimate natural hydrological regime of the Celone river and the Range of Variability Approach (RVA) has been used to evaluate the hydrological alterations of natural regime. The Range of Variability Approach, in a non-parametric analysys, was also used for a preliminary assessment of the EF as a range between the 25th and 75th monthly flow percentile.

The results of the present work demonstrate that the SWAT model is able to predict hydrological processes, although extreme low flow conditions can constitute a critical point in modeling streamflow. A high interval was found in the uncertainty analysis in low flow conditions, which means that the use of qualitative observations made by the inhabitants is very important to define the zero flow thresholds (simulated streamflow corresponding to dry conditions).

The RVA was applied for estimating the hydrological alteration in a river section -downstream the dam- by using 32 hydrological indicators (HIs) derived from historical daily flow in natural conditions (simulated by the SWAT model) and in current conditions (measured flow post impact). The results show that most of IHAs are highly altered after the dam was built, especially the indicators representing magnitude (average monthly flow from December to July, and the 1-, 3-, 7-, 30-day max), the duration (Zero days) and timing (date of min and maximum). In particular, it has been always recorded that the following indicators: 1-, 3-, 7-, 30, 90-day minimum flow are zero.

Keywords

Temporary river, hydrological Indicators, dam, hydrological regime alterations

Evaluation of the Groundwater Use Impact on the Drying Stream by Modifying SWAT Groundwater Balance Equation

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Abstract

The drying stream phenomenon was evaluated using Soil and Water Assessment Tool (SWAT) model. Among the reasons contributing to the phenomenon, the increase of groundwater use can be one of the main factor with consistent increase of greenhouse cultivation in rural areas. For a drying stream progressed watershed (398.8 km²), the SWAT was calibrated and validated using 11 years (2005 to 2015) streamflow and groundwater use data with an average Nash-Sutcliffe model efficiency of 0.72. To evaluate the groundwater use impact on the drying stream, we applied and modified the SWAT shallow aquifer water balance equation in two parts. Firstly, the groundwater use was applied to $W_{pump,sh}$ parameter which is the amount of water removed from the shallow aquifer by pumping. Secondly, we calculated the return flow of groundwater use to stream by introducing a return flow rate (*Ratereturnflow*) parameter to the shallow aquifer equation. For the SWAT simulation with $W_{pump,sh}$ and *Ratereturnflow* for 40 years from 1976 to 2015, the 10-day minimum flow (Fmin10) decreased 0.16 m³/sec. The days count of Fmin10 below annual average increased 27.3 days by the groundwater use and return flow consideration.

Acknowledgements

This research was supported by a grant (17AWMP-B079625-04) from the Water Management Research Program funded by the Ministry of Land, Infrastructure and Transport of the Korean government.

Keywords

SWAT, Groundwater use, Drying stream, Return flow, Return flow rate

Towards multifunctional agricultural landscapes in Europe: SWAT as a key to asses synergies and trade-offs between ecosystem services and biodiversity

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Abstract

The BiodivERsA project TALE develops procedures to quantify synergies and trade-offs among different ecosystem services, such as food and biomass provision or water regulation, and biodiversity, but also the effects of widely debated land use strategies such as land sharing / land sparing. This is done for a set of representative European agricultural landscapes in Germany, Switzerland, Austria, The Netherlands and Spain. The project is following a four-tiered procedure: (1) An in-depth analysis of land use policies for the five case study regions provides necessary information for (2) the development of a set of stakeholder-based land use scenarios. These feed (3) biophysical and statistical models to evaluate the effects of land sharing and land sparing strategies and constrain (4) an NSGA-II-based land use optimization procedure (CoMOLA) to identify feasible solutions with minimal trade-offs between agriculture, ecosystem services and biodiversity. SWAT is one of the models utilized for both, the scenario and optimization runs. In this presentation, we will introduce the project TALE and show preliminary results for the German case study where SWAT is used to predict crop and water yields as well as nutrient and sediment loads. We emphasize crucial SWAT-related issues such as model calibration and a proper set up of the agricultural management, but also depict how SWAT can be used in a multi-objective land use optimization framework with other (e.g. biodiversity) models in parallel.

Keywords

ecosystem services, trade-offs, crop yield, water yield, nutrients, sediments, agricultural management, model calibration, multi-objective optimization

Evaluation of Soil Water Assessment Tool for the simulation of preferential contaminant transport in cultivated lands near Zarqa river

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Abstract

Field measurements using tension infiltrometer in soils near Zarqa river basin strongly suggested the existence of preferential flow. The results of the field investigation showed that the average microscopic length (λm) is 127.4 mm. Generally, λm greater than 120 mm is indicative of preferential flow. The fact that contaminants can move preferentially in soils along the main reach of Zarqa river basin is alarming due to the utilization of treated waste water from the nearby Khirbat El Samara for the irrigation of the cultivated land in the Zarqa river valley, thus, risking the contamination of the underlying ground water resources.

SWAT is the commonly used for the assessment of long term management plans in Zarqa river. It is imperative, therefore, to assess SWAT handling of preferential contaminant movement. The simulation of preferential flow and transport requires specific physical parameters to account for macropore flux and preferential pathways within the soil profile. An additional challenge would be the upscaling the observations from the field scale at which they were obtained to the watershed scale required for the parameterization of the SWAT. Geostatistical representation may partially bridge the gap between the two scales, more importantly however is comparison between the SWAT simulated results of contaminant movements and transport processes occurring at the observation scale. Therefore, as an intermediate step, the preferential contaminant transport processes will be assessed at different selected intersections along Zarqa river basin using HYDRUS 3D. The results of the numerical model will then be compared with SWAT simulations. The expect outcome are: (1) suggest strategies for the handling of preferential contaminant transport in SWAT (2) propose improvements on SWAT to enhance the handling of lateral preferential flow and transport in Zarqa river.

Keywords

Preferential tranport, numerical modeling, Zarqa river, macropore flux, waster water

Field Observations and Model Simulations of an Extreme Drought Event in the Southeast Brazil

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Abstract

An historical secular drought in Southeast Brazil during December 2013 thru January 2015 impacted the main supply system for the Region of the metropolitan area of São Paulo city (RMASP), the Cantareira water reservoirs. About 8.8 million people were affected by water shortage, which includes domestic, industrial and agricultural uses, at the RMASP and neighbor cities, that led to an unprecedented water crisis regionally.

At the main reservoir of Cantareira system, the Jaguari/Jacareí reservoir (JJR), that contributes to approximately 76% of the total, the measured rainfall decreased by about 40% below average, and discharge by about 80%.

We used the Soil and Water Assessment Tool (SWAT) model (version 2012) to assess the impacts of the drought on the hydrological fluxes, namely the evapotranspiration, the soil and aquifer water storage and the runoff components.

The model was run for the JJR watershed during the period Apr 2011 to Dec 2016, forced by climate data from CFSv2 analysis and by several rain gauge stations placed in the drainage area, and calibrated with a discharge gauge near the inlet of the reservoir.

Keywords

drought, Cantareira system, evapotranspiration, runoff

Comparison of Interpolation Methods for Precipitation Data in a mountainous Region (Upper Indus Basin)

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Abstract

The continued improvements in computation capabilities and the subsequent increase in the development of spatially explicit and distributed models for expressing environmental phenomena has necessitated the provision of more intensive and improved data for environmental variables both in space and time for use in such models. Here the quality of the input data, especially, of precipitation, is the most important factor capable of influencing the simulation results of hydrological models, so that any errors in the input are amplified in the output, e.g. the catchment discharge. Additionally, the output of a distributed hydrological model is also sensitive to the locations and distribution of the rain gauges within the catchment and, therefore, to the spatial variability of the climatic variables, too. All this means areal precipitation should be estimated with highest care. All the hydrological model usually use, one method or another, to assign or interpolate weather data to sub-units of the study basin. Soil and Water Assessment Tool (SWAT) hydrological model do this by utilizing method based on "Nearest Neighbours, so that for any sub-basin the amount of precipitation (and other parameters) is taken from the nearest station. In cases, especially where there is low density weather stations network, this method can result in assigning unrealistic or unrepresentative values to sub-basins and subsequently compromising the quality of the results.

To solve this issue, six different interpolation methods are applied to improve the spatial coverage of rainfall data in the Upper Indus Basin (UIB). These are NN, IDW, OK, SK, KED and SKIm. The quantitative cross-validation showed that, based on the performance indicators r², MAE, RMSE, and NSE, method SKIm performed best for data aggregates at monthly, seasonal and annual time scale, followed by methods SK, OK, KED, IDW and NN in decreasing order.

According to several qualitative evaluation indices, which are based on representation of observed events and no events by the modelled daily data (Ac, FBI, POD, FAR, CSI and TSS), the estimates generated by SKIm were also better than those of the other methods, with the best average rank of 1.83. The remaining interpolation methods also performed in almost similar fashion with regard to the quantitative cross- validation indicators r², MAE, RMSE, and NSE. The SKIm method was followed in performance by SK, KED, OK, IDW and NN, in decreasing order. Overall, SKIm proved to be the best option for interpolating precipitation data in the Upper Indus Basin-UIB, while providing, in comparison to the other methods used, a better representation of the precipitation in terms of magnitudes as well as occurrences.

Keywords

Interpolation; Nearest Neighbours (NN); Thiessen polygon; Inverse Distance weighting (IDW), Ordinary Kriging (OK); Simple Kriging (SK); Kriging with External Drift (KED); Simple Kriging with Local varying Mean (SKlm); Upper Indus Basin; Hydrological Modelling and Precipitation; Accuracy (Ac); bias score or frequency bias index (FBI); probability of detection (POD); false alarm ratio (FAR), critical success index (CSI) and true skill statistics (TSS)

Hydrological analysis for representative small catchments in Caatinga and Cerrado biomes using SWAT model

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Abstract

The study and research in catchment networks is relevant for hydrological processes modeling validation, and also for comparative analysis. For this propose, the REHIDRO network was created, funded by the Brazilian Government (MCT/FINEP/CT-Hidro) and integrating the Semiarid Network of Experimental and Representative Basins (REHISA), focused on hydrological studies in catchments located at Caatinga and Cerrado Biomes, and also including transition zones between the Caatinga and the Atlantic Forest. The objective of this study was to evaluate the performance of calibrated and validated SWAT model parameters in experimental basins on other similar experimental basins, in order to identify dominant hydrological components in semiarid environments. Five catchments were analyzed: Alto Ipanema experimental catchment, fully located in the Caatinga biome; Experimental Catchment of Lago Descoberto in the Cerrado biome; Mundaú and the Japaratuba Mirim Catchments in the Caatinga and Atlantic Forest biomes. Catchments were compared based on their physical characteristics (climate, soil types, slope, circularity ratio, and land use). The most sensitive SWAT model parameters for the Alto Ipanema and Alto Jardim (Lago Descoberto) experimental basins were compared and adopted (ALPHA BF.gw, CN2.mgt, GWQMN.gw, SOL_K.sol and CH_N2.rte). Both catchments are intensively monitored, although presenting contrasting hydrological regimes, as the former is an ephemeral basin. Hydrological modelling was carried out in similar catchments in size and land use (Japaratuba Mirim and Mundaú). Rainfall time series for 2015 in the Alto do Ipanema Catchment were used. SWAT simulations produced (HIGHER/LOWER) runoff for Japaratuba Mirim and Mundaú catchment, due to increase the 11% and improvement in statistic coefficients. Adoption the most sensitive parameters in source catchments were significant to dominant hydrological component, such as runoff and evapotranspiration and other parameters the water balance in Japaratuba Mirim and Mundaú.

Keywords

experimental basins; catchment networks; REHIDRO; REHISA

Impacts of climate variability and water resources development on river flows and water balance of Huai Luang Watershed, Thailand

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Abstract

Huai Luang Watershed which located in Northeaste Thailand is facing challenges in water resources management due to increasing climate variability and expansion of urban and irrigation areas. Increasing trends of rainfall amount, rainfall variability and extreme rainfall events were observed in the basin. This study aims to assess the impacts of climate variability and water resources development on river flows and water balance in the Huai Luang Watershed over last 30 years (1983-2012) to support integrated water resources management and climate change adaptation planning. SWAT model was used to determine river flows in sub-basins of the Huai Luang Watershed and WEAP model was used to assess water demands and water balance at district level. Changes in river flows and water balance were investigated by comparing 2 periods of model simulated results between 1983-1997 and 1998-2012 (15 years each). The study shows that river flows during 1998-2012 increased by 26% compared with the simulated results during 1983-1997. Irrigation water demand during 1998-2012 has increased by 20% (250 million m³) and domestic water demand has increased by 45% (13 million m³) when compared with water demands during 1983-1997. Out of 58 districts, 33 districts have irrigation supply less than 50% of water demand and 23 districts have domestic water supply less than 70% of water demand. It is also found that Irrigation and domestic water shortages in upstream districts are much higher than downstream districts.

Keywords

Huai Luang Watershed, SWAT, WEAP, water balance

Sharing input and outputs data for large scale applications of SWAT with OGC web services

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Abstract

There are a variety of social, economic, security, and technological reasons that may limit access to data, but the problem, in general, is that the data either do not exist or are scarce, restricted, or are not in a readily-usable format. There are many emerging technologies to address limitations of data scarcity, such as sensor networks. which can make a once tedious and costly process simple to manage and inexpensive to implement. The pervasiveness of certain data, such as satellite imagery, can be combined with novel analysis techniques to provide modeled estimates of data that are scarcer. There are a plethora of data formats and distribution methods; however, if the intention is to increase the ease of use and distribution then a common interchange format must be used. The Open Geospatial Consortium (OGC) has established a method for this with the creation of standardized web services, as a way to access a dataset through a simple web address. In order to provide quality and timely data to inform evaluation and decision processes, existing Earth Observation infrastructures must be improved. Data sharing is explored in the Black Sea catchment with Geonode, which is an Open Source Geospatial Content Management System and Bringing GEOSS services into practice capacity, which is a capacitybuilding material that aims at teaching how to configure, use, and deploy a set of open source software to set up a spatial data infrastructure (SDI). Once the data is acquired and shared it can be more easily processed. These technologies are being demonstrated in the large scale Black Sea catchment that is facing important demographic, climatic and landuse changes. The limited access to reliable time-series on environmental, statistical, and socioeconomical monitoring data is a major barrier to informed-policy and decision-making. To address these issues, a web-based platform was developed to enable discovery and access to key environmental information for the region. This platform covers: Landuse, Climate, and Demographic scenarios; Hydrology and related Water vulnerability and Scarcity: as well as Beach erosion. Each data set has been obtained with state-of-the-art modelling tools from available monitoring data using appropriate validation methods. These analyses were conducted using global/regional data sets. The data sets are intended for national to regional assessments, for instance for prioritizing environmental protection projects and investments. Together they form a unique set of information that is setting the scene of the Black Sea catchment according to future plausible change scenarios, both for scientific and policy purposes.

Keywords

SWAT, Black Sea catchment, OGC standard, web services, data sharing, scenarios

Overcoming challenges of large-scale SWAT applications with R: Modelling of the Amazon basin

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Abstract

Large scale hydrological modelling has several intrinsic difficulties. On the one hand, less accuracy is demanded and the spatial resolution can be reduced to save computational resources. However, a useful model must be calibrated and validated homogeneously across the basin, which requires good observational data. Furthermore, if gauging stations selected for the model lie in nested channels, the calibration of upstream sub-catchments must be done before the calibration of downstream sub-catchments, since uncalibrated flow would affect the calibration of downstream sub-catchments. The ArcSWAT interface allows the user to substitute values of any parameter for any sub-catchment (or hydrological response unit, land use type and soil layer, when applicable). However, manual substitution of parameters is prone to errors, especially when the size of the basin results in hundreds to thousands of sub-catchments. The catchment delineation for our hydrological model for the Amazon basin resulted in 3221 sub-catchments and 9476 HRUs. For the model calibration and validation we selected 38 fluviometric stations with discharge data from 1983-2010. To help with a spatially-hierarchical discharge calibration in the Amazon basin, we used R to substitute calibrated parameters obtained at each calibration round into the SWAT data-base before proceeding to the next set of gauges downstream. Our semi-automatic method is less prone to errors and allows to substitute values for all nested sub-catchments easily. Further, the presented R routine provides a documentation to track preformed changes and correct possible errors.

Keywords

Amazon basin; hydrology; large-scale modelling; R; SWAT; SWAT-CUP

Assessment of Changes in Hydrologic Regime of the Teesta River by Teesta –V Hydroelectric Power Project in Sikkim India

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Abstract

Hydrologic studies and its linkages to the socio economic and environmental bearings have been scarce in the Himalayan state of Sikkim. The Hydrological regime of the Teesta catchment is directly related to the water availability and economic activities like agriculture, hydroelectric power generation and related hazards. Hydroelectric generating projects have faced serious condemnations from the native society for their environmental and cultural repercussions. Change in catchment flow regime due to hydroelectric power projects construction, loss of productivity of land, increased rate of erosion and the impact on the social and cultural practices have manifested as the outcomes of the hydroelectric generation projects (ACT 2010).

The present study assessess the changes in hydrologic regime of the 4657 Sqkm Teesta-Dikchu watershed (name given for the present study) located 88°13'E, 28°12N' to 88°51' E to 27°20'N, by the construction of the Teesta V hydroelectric power project. The study uses the SWAT hydrological model to generate a 30 years of continues time series flow data (calibrated and validated) and the Indicators of Hydrologic Alteration(IHA) as an analysis tool to understand the changes in the 33 hydrologic parameters which are lumped into five groups: (1) magnitude of monthly flow conditions; (2) magnitude and duration of extreme flow events (e.g. high and low flows); (3) the timing of extreme flow events; (4) frequency and duration of high low flow pulses; and (5) the rate and frequency of changes in flows, before and after the construction of the Teesta V reservoir in the Teesta river channel.

The hydrological studies in the Teesta river basin have been mosly short term site specific for hydropower project construction, while the continuse time series data for an assessment study is not avaivale. Sikkim receiving an annual rainfall of 3097.78mm/yr. (Rahman et.al 2012) has significant contribution to river flow and the Teesta V Hydro Power Project dam barricade Causes changes in runoff (Tom 2014). Thus to understand the flow changes in the river Teesta caused by hydropower projects development, SWAT hydrological model was used to generate Catchment volumetric flow for 30 years using the weather data from the Indian Meteorology Department from four stations namely Chungthang, Lachen, Gangtok, Mangan, Tadond. The physically based SWAT model's ability to accurately predict stream flow in ungauged watersheds was very instumental in geerating the daily flow data. The SWAT model was successfully calibrated and validated for flow against observed flow data at Chungthang &Sankolong gauging stations.

Further the SWAT generated daily flow data was used by the IHA in two categories pre resovior construction in the main rivver channel i.e 2008 and post construction 2008-2015 period. Thus the highest hydrologic alteration factors of Teesta V dam construction pre and post construction are seen as the median of monthly flow indicating a decreasing trend compared to the pre dam construction period. While the magnitude and duration of extreme flow events show a decreasing trend indicating the daily weekly, monthly and quarterly minimum flow cycle are negatively influenced by the reservoir regulation. While the 1-day maximum, 3-day maximum, 7-day maximum, 30-day maximum and 90-day maximum show a rising trend of the daily weekly, monthly and quarterly minimum flow cycle. The timing of extreme flow events are such that the median Julian dates of each annual 1-day minimum move forward from the 182nd day in the pre-impact period to the 237th day in the pre-impact period to the 211th day in the post-impact period. Frequency and duration of high low flow pulses count is higher than those in the pre-impact period is lower than those in the pre-impact period. The rate and frequency of changes in flows increased. The coefficients of dispersion of rise rate fall rate and number of reversals are higher than in the earlier period.

Keywords

Teesta ,Hydrologic Alteration, Sikkim, SWAT, IHA

Automated implementation of irrigation in SWAT

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Abstract

Irrigation practices have a huge influence on the hydrological cycle and the results of climate change impact studies and hence need to be properly represented in catchment models. While SWAT incorporates routines that represent irrigation, manual adaptations to the model are often required. Applying such adaptations becomes a tedious task when the SWAT model is applied on a large-scale. In this paper, we present a workflow that allows for the representation of irrigation practices with minimum manual manipulations. This work builds upon PAIC-SWAT; an existing interface for setting up SWAT models which was implemented in python. In this study, a module is added and the interface is adapted to allow an irrigation map to be used for identifying Hydrologic Response Units (HRUs) with irrigation. Auto irrigation is implemented in the identified HRUs using the added module. Later, irrigation can be included in automatic calibration using SWATCUP.

Keywords

SWAT, Auto Irrigation, Modelling, Model Setup, PAIC-SWAT

Using Multi-Criterea Calibration Methods to Estimate Nitrate Pollution in a Large Basin with Limited Data

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Abstract

A lack of data of sufficient quantity and/or quality is a common challenge in hydrologic modelling, which can lead to a high degree of uncertainty in resulting model assessments. In such cases, it is critical to maximize the informational content from available data, making the use of improved data analysis and calibration methods an important modelling tool. This study examines a case study where an assessment of land-cover change on nitrate levels was made in a large river basin in north-central Portugal (Vouga River), for which only relatively low quality streamflow and water quality data was available. A number of input data and pre-modeling 'best practices' were applied, and a calibration method was developed which was designed to maximize the informational content of the observed basin data. This approach relies on identifying parameter sets which are Pareto efficient in terms of an adapted Kolmogorov–Smirnov test (for water quality) and Kling-Gupta efficiency measure (for streamflow). Different variations and weighting of these measures are evaluated, in terms of their impact on resulting model simulations, as well as comparisons against the use of more standard calibration objective functions. The utility of this approach for wider SWAT model applications, and ideas for further testing and development are discussed.

Keywords

Multi-Criterea Calibration, Pareto optimization, Kling-Gupta Efficiency, Nitrates, Portugal

Hydrological modeling of a tropical basin with SWAT: A study case of Cauto River, Cuba

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Abstract

Modelling hydrological behavior of Caribbean basins present many challenges due to the high dynamics of their climatic systems. Although, nowadays there is an increase availability of tools, still hydrological models of river basins in these tropical regions are scarce. One example of this is Cuba, where experimental hydrology has not widely used their results in modelling tools. This study evaluates and proposes a parametrization for the SWAT (Soil and Water Assessment Tool) model to simulate the water resources in The Cauto river basin. We explore the identification of parameters that best describe the physical characteristics in the hydrology of the region. The Cauto River basin in Cuba has been studied, however, there is no SWAT model of the region nor a clear idea of how this model parameters relate more to the water resources. The methodology presented follows a calibration and validation process for two sub-basins (La Fuente and Las Coloradas) for monthly data from 2001 to 2010 and a discussion of its generalization for the region. The parameters obtained show to have a good representation for the upper and middle region of the basin. We found that the U.S. Soil Conservation Service curve number (CN2) was the most sensitive parameter, while the soil evaporation compensation factor (ESCO) and available soil water capacity (SOL AWC) were also important. The high sensitivity to this parameter set reveals the critical nature of surface runoff processes in hydrology of the basin. Another set of parameters showing sensitivity were those related to channel processes and the base flow: the effective hydraulic conductivity in channel alluvium (CH K2), baseflow recession constant (ALPHA_Bf) and groundwater revap coefficient (GW_REVAP). Parameters have different ranges of values in each region, reflecting a difference in runoff-generating mechanisms between the two studied sub-basins. The contribution of this analysis is the assessment of the main differences between hydrological processes across the Cauto river basin.

Keywords

SWAT, Hydrological Model, Discharge, Cauto River, Cuba

A NSGA-II based calibration platform for the SWAT and other universal models

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Abstract

Model calibration is an important work in nearly all the modeling studies. In the general process of model calibration, calibrated parameters are modified repeatedly in term of running model again and again. Because of many times of model running during this process, model calibration is often time-consuming. Even many model which doesn't have any auto-calibration tool will cost many efforts in the complex operations. Thus, some easier searching algorithms are used in most models' auto-calibration tools to avoid too many times of model running but may can't get a good-enough-result. In this study, a calibration platform, which is based on cloud computing technique, is designed. This platform can synchronize many computers by network. So that the speed of calibration is improved from another way. Non-dominated sorting genetic algorithm for multi-objective optimization (NSGA-II), which has been modified for the high-concurrency circumstance, is used to search for better groups of parameters. The universal interfaces are designed reference to SWAT and some other models, make it possible to apply most models. The usage of network avoids additional hardware requirements. Case studies got gratifying results and showed a significant speed up depending on the performance of computer.

Keywords

Model calibration; NSGA-II; cloud computing

SWAT modelling approach to assess the effect of Potato Conservation Tillage (CT) on nutrients concentration and losses in runoff water in Fuquene watershed.

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Abstract

Intensive Tillage (IT) in potato crop is considered a major contributor to local water eutrophication in the Fuquene Lake of Colombia. Therefore, the local government has invested in several programs aiming for the adoption of principles of Conservation Tillage (CT) as means to arrive to Best Management Practices (BMPs). Complexity of hydrological and geological heterogeneity makes uncertain the benefit degree of CT has in different locations. In this study, assess the impacts of changing IT by CT. This is done at HRU and Watershed levels. In this way, we quantify the impacts of CT on sediments, nitrogen (N) and phosphorus (P) losses in surface water runoff from potato crop by using the Soil Water Assessment Tool (SWAT) model. To calibrate and validate the model data were used from 2011 to 2013 for nutrients and 2006 to 2013 for flows. Results suggest that CT at watershed level reduces 26% sediment yield and 11% surface runoff compared with IT, which means an overall reduction of load. The main CT effect on nutrient losses in runoff is an increase in the total N and P (2% to 18% respectively) compared to baseline. However, the results at watershed scale showed different patterns than the ones obtained at HRU (calibrated and validated). Therefore, an additional study needs to be carried out in order to make an appropriate extrapolation of CT. Despite the model uncertainties, the results provide a strong basis to facilitate development of land use plans by local decision makers, and thus be able to reduce water pollution in the Fuquene watershed.

Keywords

Hydrological model, BMPs, water quality, Andes watershed, SWAT model.

A new tool for optimizing best management practices by integrating SWAT and NSGA

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Abstract

Best management practices (BMPs) and decision support system (DSS) are the major solution to non-point source (NPS) pollution. Spatial optimization of BMPs is an important issue in the DSS. Non-dominated sorting genetic algorithm for multi-objective optimization (NSGA-II) has been widely applied in the existing related researches. But, due to the spatial optimization process requires many times' simulation, and more accurate distributed or semi-distributed hydrological models spend too long time on each simulation, figuring out satisfying BMPs in an available time is usually not possible. Instead, those researches mostly apply some simple lumped models or even single removal rate to simulate the effects of BMPs. This study designs a network system which can coordinate and synchronize many computers, in order to improve the optimization speed without reducing the accuracy of simulation. Soil and water assessment tool (SWAT) is used in the system to simulate effects of BMPs. The usage of online platform avoids additional hardware requirements. The system takes both cost and effect as evaluate factors to figure out cost-effective solutions

Keywords

Spatial optimization; NSGA-II; SWAT; cloud technique

Evaluating Impacts of Alternative Adaptation Strategies on the Dynamics of Human-Water Systems: A Methodological Framework for an Integrated Modular SWAT and Multi-Attribute Revealed Preference Model

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Abstract

The management of water resources and its provisioning to socio-economic systems are non-trivial processes requiring a holistic understanding of the factors driving the dynamics of human-water systems. Socio-economic and/or environmental changes and fluctuations can potentially alter the balance between supply and demand for water resources, particularly in vulnerable Social-Ecological Systems (SES) in arid and semi-arid areas. In basins where water supply is insufficient to meet demand during all or part of the year, water resources managers and policy makers are constrained to shift priorities from harnessing water for economic development to making withdrawals compatible with available resources. A fundamental welfare question here is how to minimise harm and maximise benefits from water reallocations. System analysis can support water resources managers in providing quantitative information regarding the impacts of alternative adaptation strategies on the dynamics of human-water systems, as long as the analysis contemplates the integrative nature of SES. Currently, purely hydrologic or economic models lack ability in describing the complex nature of coupled human-water systems. This paper presents a methodological framework that proposes the integration, following a modular approach and in a sequential fashion, of a multi-attribute Revealed Preference Model (RPM) with the eco-hydrologic Soil and Water Assessment Tool (SWAT) model. The linkage between the two modelling techniques is provided by a common spatial element, identified as the social-ecological responsive unit and defined as the result of the combination of hydrologic responsive units and socio-economic agents. The Rio Mundo watershed, part of the Segura River Basin in south-eastern Spain, is considered as a case study to demonstrate the applicability of the proposed methodological framework.

Keywords

Human-water systems; Socio-hydrology; Alternative adaptation strategies; SWAT model; Multi-attribute revealed preference model; Mathematical programming; Hydro-economic model; Water resources management.

Technical-economic analysis of best management practices for appropriate control of sediment yield: Case of Joumine river basin, Tunisia

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Abstract

Soil erosion by water is one of the main hazards affecting the agricultural productivity and the sustainable use of surface water resources. Best management practices (BMPs) have been widely used as countermeasures to limit the erosion risk, nutrients loss, and sediment loads. Furthermore, it can lead to improving the soil property and crop productivity. In this study, biophysical (SWAT model) and economic (Cost Benefit Analysis) approaches were used to investigate the effectiveness and the cost benefit of different BMPs in a cropland dominated watershed (Journie river basin, Tunisia). Firstly, SWAT model was calibrated and validated using observed streamflow and sediment loads. Then, the performance of the model was evaluated using statistical methods. Finally, the costeffectiveness of different BMPs was evaluated. The model performance for the simulation of streamflow and sediment yield was satisfactory. The model results showed that majority of sediment were produced in cultivated upland area. About 34 % of the basin area were affected by high to very high soil erosion risk (Sediment yield > 10 t/ha/year) and need the implementation of BMPs to regulate the soil erosion intensity. Contour ridges were found the most effective individual BMP in term of sediment yield reduction. At watershed scale, implementing contour ridges in 34% of the watershed's area reduced the surface runoff and sediment yield by 25% and 59% respectively. Combined BMPs scenarios were found more cost-effective than individual BMPs. Combining Vegetative Filter Strip practice (5-m width) with other BMPs depending on land slope (Slope > 20%: conversion to olive orchard; 10% < Slope < 20%: Contour ridges; 5% < slope < 10%: Grass strip cropping) was the most costeffective BMPs scenario. It can lead to reduce the sediment yield by 61.8% with a Cost/Benefit index of 1.72. Our results gave an ex-ante evaluation of integrated management practices in Journie river basin. It can contribute to an appropriate utilization of the limited allocated funds for soil and water conservation.

Keywords

SWAT model, Sediment yield, BMPs, Cost-effectiveness

Introducing Climate Change Toolkit (CCT): a modular toolkit for climate change and extreme weather analysis

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Abstract

Modeling and projection of climate change impacts need repetitive and time-consuming tasks. To overcome this challenge, we created a modular Climate Change Toolkit (CCT) to handle all required tasks by climate change analyses in one package. CCT consists of Data Extraction, Global Climate Data Management, Bias Correction and Statistical Downscaling, Spatial Interpolation, and Critical Consecutive Day Analyzer (CCDA). CCDA uses a customized data mining approach to recognize spatial and temporal patterns of extreme events. CCT is attached to a global database of five GCMs (CMIP5) of ISI-MIP (Inter-Sectoral Impact Model Inter-comparison Project) models (GFDL-ESM2M, HadGEM2-ES, IPSL-CM5A-LR, MIROC-ESM-CHEM, NorESM1-M) and four Representative Concentration Pathways (RCP2.6, RCP4.5, RCP6, and RCP8.5) for the years (1950-2099) and historic data from Climate Research Unit (CRU) (1970-2006). All climate databases are at 0.5° spatial resolution and are available at <u>www.2w2e.com</u>. All climate data are compatible with SWAT input format, and users can use CCT and SWAT to analyze the impact of climate change on water resources components and frequency extreme events in the future.

Keywords

extreme events analysis, climate change, big data, CMIP5, SWAT

Assessing the impacts of climate change on discharge and nutrient losses from a karstic agricultural sub-basin in the Upper Chesapeake Bay watershed

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Abstract

The health of the Chesapeake Bay Basin ecosystem, which lies within the heavily populated Northeastern United States, relies on reducing nutrient loading to the Chesapeake Bay by the 2025 TMDL deadline and on into the future. Doing so requires evaluating the impact of current agricultural management practices within the Basin and determining how these practices may need to evolve in response to climate change. Numerous modeling efforts have explored the efficiency of proposed best management practices that can be implemented to reach that goal. However, the karstic geological nature and variable source area (VSA) hydrology of the Valley and Ridge physiographic province within the Upper Chesapeake Bay represent particularly interesting hydrogeologic challenges in such modeling. Spring Creek Watershed, a representative agricultural sub-basin with karst geology and VSA hydrology within the Chesapeake Bay watershed in south central Pennsylvania, is 34% agriculture, 23% developed, and 43% forested. We used the Spring Creek Watershed realization of Topo-SWAT, a version of SWAT that incorporates variable source area hydrology, to investigate the discharge and nutrient losses from the watershed in 2015, 2025, 2050, and 2075 under current and projected climate conditions and current land use and land management practices. The climate projections were generated from nine coupled Model Intercomparison Project Phase 5 (CMIP5) models run under both high and intermediate emission scenarios and downscaled to point locations in the northeastern United States. Preliminary analyses of the climate projections show sharp increases in annual and, especially, fall and winter total precipitation plus narrowing mean annual diurnal temperature ranges in the Spring Creek watershed over the 21st century. Results from Topo-SWAT will characterize the variability of potential watershed responses to the different climate forcings. An examination of these potential climate change impacts on nutrient loads discharged at the watershed outlet and the associated agricultural management practices will be used in future work to guide development of a focused restoration strategy for this and similar watersheds within the Chesapeake Bay Basin.

Keywords

hydrology; warming; environment; nitrate; phosphorus; transport

Climate change impact on streamflow in ISI-MIP large-scale river basins: projections and their uncertainties

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Abstract

Climate change impact on river runoff was investigated using the physically-based land surface model SWAP developed in the Institute of Water Problems of the Russian Academy of Sciences. Twelve large-scale river basins suggested within the framework of the ISI-MIP project were used in this study. For simulating runoff at the river basin outlets, schematization of each basin as a set of 0.5°x0.5° computational grid cells connected by a river network was carried out. Model parameters for each grid cell were taken or derived from the ECOCLIMAP data set after its aggregation for 0.5 degree grid cells. Soil parameters were derived from the values of Clay and Sand given in ECOCLIMAP. Meteorological forcing data (including precipitation, air temperature, shortwave and longwave downward radiation, air humidity, wind speed, and air pressure) for historical period (1969-2001) needed for model calibration and validation were taken from the WATCH data set with one-day time step.

Simulations of river runoff for the historical period performed by SWAP with *a priori* input data showed a poor agreement with observations. Calibration of a number of model parameters against measured monthly river runoff using SCE-UA optimization algorithm resulted in substantial improvement of model performance with respect to goodness-of-fit statistics and the shape of hydrograph.

Climate change impacts on river runoff were studied using meteorological projections (for 2005-2100) from five General Circulation Models (GCMs) (including GFDL-ESM2M, HadGEM2-ES, IPSL-CM5A-LR, MIROC-ESM-CHEM, and NorESM1-M) under four RCP scenarios (RCP2.6, RCP4.5, RCP6.0, and RCP8.5). All GCMs' projections were bias-corrected to WATCH within the framework of the ISI-MIP. First of all, we performed historical simulations of streamflow for 12 river basins using the SWAP model and meteorological outputs from the five GCMs. Satisfactory agreement between simulated and observed mean monthly runoff was obtained for nine river basins. Then, for each of these basins, 20 projections of possible changes in river runoff during the 21st century were simulated by SWAP. Analysis of the obtained hydrological projections allowed us to estimate their uncertainties resulted from application of various GCMs and different RCP scenarios.

Keywords

climate change impact, ISI-MIP, model SWAP, RCP scenarios, river runoff, hydrological projections, uncertainties

Using real runoff instead of natural runoff to evaluate impact of climate change on hydrological drought in order to consider human activity by SWAT

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Abstract

Most studies evaluating the impact of climate change on hydrological drought, by using natural runoff. An important factor that is ignored, is role of human activities on severity of drought in terms of climate change. This study at the same time, evaluate impact of climate change and human activities on hydrological drought by using real runoff (considering dam and agricultural) that is simulated by SWAT model in Zarineh rud basin. For this purpose the SWAT model was calibrated and validated and was run in baseline period (1981-2010). The real runoff all over sub-basin derived from SWAT model was used to calculate the SRI index. Then by introducing average of downscaled results of AOGCM models (AR5) under two emission scenarios to the SWAT, SRI index was simulated during future period (2017-2046) and were compared against baseline period. In final by selecting one adaptation strategy in agricultural section and recalculating SRI and comparison with the amounts before adaptation the performance of this strategy was evaluated. The obtained results indicated that Basin of Zarineh rud is still in danger of continuous and long term droughts due to current trend of human activities and possible climate changes in near future. Adaptation strategy results is effective in hydrological drought and decrease in total intensity. analyzing future drought characteristics, with evaluating different levels of drought under the effects of expected climatic change and by considering human activities surely will provide a more realistic view and a better preparation in contrast to negative effects of this phenomenon.

Keywords

climate change, drought, SWAT model, standardized runoff index (SRI), Zarineh rud

A comparison between SWAT and WETSPA hydrological models for riparian fen modelling at the catchment scale

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Abstract

The importance of wetlands for both natural environment and human well-being can be demonstrated by highlighting the vast amount of ecosystem services that they are providing. Among these, natural water retention is an important ecosystem service, limiting the impact of the flooding and releasing water in dry periods, and therefore regulating a river flow. Thus, including wetlands zones in a hydrological modelling, may improve the quality of flow simulations. However due to complexity of wetland hydrological processes, this is a challenging task.

In the framework of the HiWET project, we aim for an improved simulation of wetland processes in the Upper Biebrza basin (Poland) using evapotranspiration (ET) obtained from remote sensing data and a local flux tower as a key variable evaluate to identify the wetland processes and functioning. In this study, the ET simulations of two hydrological models, SWAT and WETSPA are evaluated with ET estimations derived from the Eddy Covariance (EC) tower. The SWAT model conducts ET simulations based on the HRU (Hydrological Response Units) level using Penman-Monteith and Hargreaves methods. The fully distributed WETSPA model used Penman-Monteith to simulate ET at 30 meter grid-scale. This modelling exercise have provided a deeper insight into the problem of wetlands simulation, gave knowledge about the current capacity for accurate modelling and inspired the HiWET team to search for new ways to overcome the limitations of those models.

Keywords

WETSPA, SWAT, Biebrza, hydrological modelling

Comparative hydrology using the SWAT model in Pernambuco State watersheds, Northeast of Brazil for SUPer system development

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Abstract

Regarding current problems related to sustainability, water resources conservation and forecasting and control of extreme rainfall events, there are several challenges, and in order to overcome those challenges, the number of published studies in comparative hydrology field have been increasing. The objective of this work is to perform a comparative analysis between observed and simulated properties in experimental and representative basins of the semiarid region of Northeast Brazil, using the SWAT model. For that, we selected four Pernambuco State basins: Alto Ipanema, Brígida, Pontal and Mundaú. These watersheds have been served as the base for developing a system of hydrological response units for the State of Pernambuco called SUPer. We analyzed and compared climate, soil, slope, morphometric parameters (circularity ratio, hypsometric curve and mean stream length) and land use characteristics from all the basins. We performed a sensitivity analysis of model parameters using the Sensitivity Analysis Tool available in the SWAT-CUP software. This analysis is important to verify the most sensitive parameters for each studied catchment. The interval of temporal climate data used for Calibration and simulation processes varied among the watershed based on data availability and consistency for each area. For the Alto Ipanema basin, we used data from 2000 to 2015; for Pontal, from 2005 to 2010; and for Mundaú, from 2000 to 2016. Considering physical and hydrological characteristics of each study watershed, we analyzed and compared, after calibration, the parameters values obtained for each area to verify whether those values can be or not considered as regional reference values. We found the most sensitive parameters were CN2.mgt, and GWOMN.gw for three of our basins, with values ranging from 51.4 to 81.89 (CN2.mgt; Alto Ipanema), 0 to 885 (GWQMN.gw; Alto Ipanema, 28.14 to 78.99 (CN2.mgt; Pontal), and 36.6 to 110.4 (CN2.mgt; Mundaú), 0 to 4000 (GWQMN.gw; *Mundaú*). For *Pontal*, SOL_AWC.sol was in second place among the most sensitivies with an interval of values from 0.027 to 0.147.

Keywords

Hydrological modeling, sensitivity analysis, calibration

Assessing the Influence of Climate Datasets for Quantification of Water Balance Components in Black Sea Catchment: Case Study for Melen Watershed in Turkey

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Abstract

Precipitation is one of the predominant input affecting the hydrological processes, sediment, and nutrient transportation in catchment areas. Choosing representative climate dataset has significant importance to obtain accurate model results especially in a mountainous region where the spatial distribution of the local climate stations shows high spatial heterogeneity which cannot capture entire catchment area. This study is carried out to investigate the influence of the different climate data input on modeled streamflow and hydrological components of the Melen Watershed which is located in western Black Sea coast of Turkey. To achieve this, Climate Forecasting System Reanalysis (CFSR) and local weather data are used to drive the Soil and Water Assessment Tool (SWAT), between the years 2000 and 2013 which is common period for both dataset. Calibration and validation procedure are conducted by using SWAT-CUP software with the SUFI-2 algorithm based on daily meteorological and monthly streamflow data at several hydrometric stations. Model performances for the different dataset are evaluated by comparing simulated and measured streamflow data in the watershed. Overall results have shown that recorded precipitation data underestimated the rainfall over the of the study area. Due to the model results, CFSR outperformed the local dataset; captured the streamflow dynamics also estimated better total rainfall distribution over the study area.

Keywords

CFSR, Melen Watershed, SWAT Model, weather data input

A methodology for calculating the Water Accounting and Water Productivity based on SWAT-T simulations. Case Study: Mara Catchment

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Abstract

Water resources users and managers face the challenges of the climatic change, in basins that already experience water scarcity, the situation may be even worse. In addition, a growing population leads pressure on land and in turn increased the water demand mainly in order to meet the demand for agricultural production, the agricultural areas are expanding. There is a clear need for sustainable water resources management, through increased water productivity, increasing the yield production with less water. Water Productivity, defined as production per unit of water consumed, is an indicator of the performance of agricultural production systems, giving reports of the status of the basin. On the other hand, Water accounting frameworks have proven to be a supporting tool, because the results are summarized in accounting sheets. This study presents the spatial and temporal outputs of physical water productivity and water accounting sheets based on SWAT simulations, being a helpful easy-to-understand source needed to support decision making and to improve the water resources management. SWAT has proven to be a robust tool that it can be used to evaluate the impact of land management practices on the environment. An improved version, SWAT-T with an improved SWAT plant growth module, especially for basin across the tropics, was successful in simulating the major water balance components in Mara Catchment. In this study, we coupled SWAT results to Python codes for Water Productivity and Water Accounting as developed by IHE-Delft. We applied the coupled methodology in the Mara Catchment, a transboundary basin between Kenya and Tanzania.

Keywords

SWAT, Water Productivity, Water Accounting, Python, Mara Catchment
Impact analysis of land sharing vs. land sparing strategies on catchment-scale agroecosystem services using SWAT

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Abstract

Landscapes dominated by agriculture are managed to provide products such as food, feed and fiber. However, the production of these goods is in potential conflict with the provision of various other ecosystem services such as nutrient cycling, soil protection, water provision, and maintenance of biodiversity. This raises the question of how agricultural landscapes could be managed to reduce such conflicts and to achieve synergies between several ecosystem services. The study aims at evaluating the potentials of land sparing vs. land sharing strategies to succeed in that respect. Local stakeholders in the Broye catchment in Western Switzerland defined scenario options for both strategies. Impacts of these scenarios on water quantity, water quality, soil loss, and crop production are evaluated using the model SWAT (Soil and Water Assessment Tool).

Available data for model calibration include daily river discharge and nitrate concentration, as well as estimates of crop yields. For model calibration, a two-step approach for water quantity and quality is used: in a first step, the model is parameterized and calibrated for discharge at a daily time step to identify sensitive flow parameters; in a second step, water quality parameters are added, and a multi-objective calibration approach is used to optimize all selected sensitive parameters. Crop parameters are manually adjusted if the simulated result of crop yield is not satisfactory. After validation, the model is run for the different scenarios to quantify the impacts of different land management strategies at the catchment scale on crop yield, water quantity, nitrate concentration in surface water, and soil loss. Most recent key outcomes of the simulations will be presented.

Keywords

land use, land management, land sharing, land sparing, agroecosystem services, SWAT, discharge, water quality

Modelling vulnerability of coastal ecosystems to land-based mining pollution: a case study from Brazil

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Abstract

Land-based pollution can have major impacts on marine biodiversity worldwide. However, little is known about how the potential impacts of ongoing mining activities operating within coastal watersheds, or to what extent receiving marine ecosystems (e.g. coral reefs) are considered at risk. The main sources of pollution are increased loads of sediments and residue spills of toxic contaminants resulting from failures of tailing dams in mining enterprises. As demands for mineral production are expected to grow over the coming decades, there is a need for methods that enable a vulnerability assessment of the potential impact of these sources of pollution on coastal ecosystems, particularly with respect to damaging events following dam collapse. We address this gap by presenting a framework that combines data on exposure and intensity of mining activities in Brazil, which could be used to quantify spatial gradient of vulnerabilities and risk. Our study focuses on the watersheds hosting Brazil's largest iron mining region. We use the SWAT (Soil and Water Assessment Tool) model to simulate mine spill events and quantify potential magnitude in end-of-river loads of sediments and contaminants. We then couple SWAT with marine biophysical models to estimate potential influence of dam failure events across mapped coastal ecosystems. Given the recent collapse of a major mining dam in southeastern Brazil, our study provides a timely conservation tool that could be useful in future efforts to prevent and mitigate the deleterious effects in the aftermath of catastrophic events.

Keywords

vulnerability assessment, conservation, hydrological modelling, risk

Parameter Calibration of SWAT Hydrology and Water Quality Focusing on Long-term Drought Periods

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Abstract

The SWAT (Soil and Water Assessment Tool) has been calibrated to understand the watershed hydrology and water quality for better watershed management. Since 2000, 9 droughts have visited in South Korea with abnormal return periods and duration. The droughts have affected the amount and shape of flow hydrograph and the water quality concentration. For the long-term period of drought, the SWAT calibration parameters may be different to get a good statistical of model between observed and simulated ones. In this study, a 366 km² Gongdo watershed located in northwest part of South Korea was adopted with 14 years (2002-2015) data. The SWAT Nash-Sutcliffe model efficiency (NSE) for Q and 1/Q focusing on 2 drought years (2014-2015) calibration (C₂₀₁₄₋₂₀₁₅) were 0.86 and 0.76 while the NSE focusing on 5 normal years (2002-2006) calibration (C₂₀₀₂₋₂₀₀₆) showed 0.78 and 0.58 respectively. The SWAT determination coefficient (R²) of Sediment, T-N, and T-P for C₂₀₁₄₋₂₀₁₅ showed 0.71, 0.65 and 0.62 while the R² for C₂₀₁₄₋₂₀₁₅ was 0.63, 0.58 and 0.48 respectively. The 9 parameters of CN2, CANMX, ESCO, SOL_K, SLSOIL, LAT_TIME, GW_DELAY, GWQMN, ALPHA_BF affected for the hydrology calibration and the parameters of N_UPDIS (Nitrogen uptake distribution parameter) and CMN (Rate coefficient for mineralization of the humus active organic nutrients) played an important role for the water quality calibration during drought periods.

Acknowledgements

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

Keywords

SWAT, Parameter, Watershed Hydrology, Water quality, Long-term Drought, Calibration

Discussion of a Decade Accumulative Assessment from Baseline for Future Climate Change Impact on Watershed Hydrology and Water Quality Using SWAT

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Abstract

This study was designed to investigate projected results of future time periods, by using a decadal accumulative evaluation approach relative to the baseline time periods. This results in successive future distinct decades for evaluating model outputs; e.g., 2010-2019, 2010-2029, 2010-2039, 2010-2049. Practically, the government requests the adaptation plan for watershed management by climate change, for example, until 2020 or 2030 from present. The Soil Water and Assessment Tool (SWAT) was applied for the Han river basin (34,148 km2) in South Korea, by dividing the basin into 184 sub-basins and accounting for the water resource facilities of 4 multipurpose water supply dams and 3 multi-purpose diversion dams. The SWAT model was calibrated (2007-2010) and validated (2011-2014) using daily observed stream flow and water quality data at 7 locations. The Nash and Sutcliffe model Efficiency (NSE) for the streamflow was 0.59~0.88, and the average R2 for the sediment, T-N, T-P was 0.75, 0.70, and 0.73, respectively. The climate change impact on watershed hydrology and water quality, using the HadGEM3-RA Representative Concentration Pathway (RCP) 8.5 scenarios, were traced from 2010 to 2069 in a successive way. We found that the watershed hydrology was mainly affected by the future temperature and rainfall changes and that the water quality was dominantly affected by the sources of point and nonpoint pollution. From the results of a decadal accumulative evaluation from 2010-2019 to 2010-2069, we found that this kind of evaluation can provide more insight and better identify processes for the spatiotemporal changes in hydrology and water quality behavior that will occur in near-term future time periods.

Acknowledgements

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

Keywords

SWAT, Climate change, Hydrology, Water Quality, and Watershed

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