

Interactive comment on “Impact of LUCC on Streamflow using the SWAT Model over the Wei River Basin on the Loess Plateau of China” by Hong Wang and Fubao Sun

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Subject: Revise the manuscript (#hess-2016-332)

The Authors: Wang & Sun

The Title: Impact of LUCC on Streamflow Based on the SWAT Model over the Wei River Basin on the Loess Plateau of China

Response:

The authors appreciate Dr. Lacombe for helpful criticism and 8-pages constructive

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comments that improved our original manuscript. We have addressed the comments below and have made corrections. The changes being made are marked in red in the manuscript.

Response to the main comments:

1: First of all, I am questioning the significance of the hydrological changes that actually occurred in the catchment over the studied period. Although figure 1 indicates that forested areas increased by about 65.104 hm² (unusual unit used on the Y axis), which is equivalent to 14% of the upper catchment area, figure 3 inconsistently shows that forested area increased by only 0.81% (line 137) over the same period (1980 to 2005). How to explain this difference? If we rely on figure 2 (which is likely the most reliable source), we can expect minor influence of forestation on the basin hydrology.

Thank you for pointing this out, which makes us think it through. In fact, these two datasets are from different sources. First of all the number in Fig. 1 is for 6.53% (instead of 14%) as shown in detailed explanation below, which is still higher than 0.81% as pointed by the referee. This is a classic issue in the national survey on soil and water conservation where they only take the revegetation implemented into account and ignore for example possible death of vegetation, which is important in the land use map. One more thing is that the national survey when counting the revegetation areas does not consider the vegetation coverage, which is in fact important in any hydrological modelling including the SWAT modelling. We agree with the referee on that point. With that caution, however, Figure 1 is just for a reference on the development of the soil and water conservation project in China. The data we are relying on are the land use maps. Detailed explanation below:

(1) There are some detailed descriptions about Fig.1. The same legends for Fig.1 (a) and (b) brought some confusion, so we revised the legends of Fig. 1. Figure 1 is the developing process of the soil and water conservation measures in the main stream basin of Wei River, including the upper and middle reaches (4.68×10^4 km²) and the

downstream of the main stream (1.65×10^4 km²). Figure 1 involves about 6.33×10^4 km². Figure 1 (a) is the area developing of forestation, terraces, grass and dam land separately. The area of forestation was about 57.43×10^4 hm² during 1980s and it increased to 98.75×10^4 km² in 2006, which equivalent to 6.53% of the main stream basin of Wei River. And Fig. 1 (b) is the sum area of the forestation, terraces, grass and dam land in upstream, midstream and downstream. And the sum area increased by about 66.15×10^4 hm² in upstream.

Fig. 1 The development of soil and water conservation measures in the main stream basin of Wei River over last 50 years.

(2) Figure 1 is the statistical data of government based on natural forest before and artificial planting area, which involves all planting of forestation without considering canopy density, surviving or deforestation and so on. The forest of the LUCC data refers to the natural forest and plantation, which canopy density is larger than 30% (Table 3: note "a").

(3) The forest data of Fig. 1 also includes planting land used as agro-fruit, agro-mulberry, agroforestry and replanting land for trees. While land used for agro-fruit, agro-mulberry, agroforestry is classed as Agricultural land (Table 3: note "a") in LUCC.

(4) There are also some screening conditions for land use types dividing in SWAT model. For hydrological response unit (HRU) analyst, the Dominant Land Use method was used for HRU definition. So the dominant unique combination of land use in the subbasin is used to simulate the HRU. Figure 1 shows the area of grass is smaller than forest's, while it is opposite in LUCC and SWAT model attributed to canopy density and the Dominant method.

(1) The main issue of this paper is that all the demonstration relies on simulated flows only. Flow simulated over the period 1980-2009 with land-use from 1980 should be compared to actual flow recorded over the period 1980-2009.

Thank you for your comments. We add a new Fig. 8 to show the time-series graph of calculated streamflow vs. observed streamflow during 1980-2009 for hydrological stations. We can see the calculated streamflow matched well with the observed values during 1980s. The observed values were measured daily based on the actual LUC, while the calculated streamflow was got based on LUC of 1980. So Fig. 8 shows the calibrated SWAT model played well in our study area and the changing LUC can affect streamflow gradually. The streamflow of typical year, the same year with LUC, is the results of by LUC and meteorological conditions. To reduce influence of meteorological condition and isolate the impact of the LUC on streamflow, 30-year average of the streamflow for forest and agricultural land were taken, respectively. For period of 1980-2009, we just used their measured and long-term daily meteorological data in the study area to drive the validated model for the designed hydrological experiments.

Fig. 8 The time-series graphs of calculated vs. observed streamflow during 1980-2009 for hydrological stations.

(2) Another issue is the implicitly presumed stability of the catchment behaviour over each of the 2 periods 1960-79 and 1980-2009. A graphic showing annual flow, rainfall (both in mm) and runoff coefficients in each of the 3 nested catchments and intermediary catchments (e.g. the colored areas in figure 2) would provide a first assessment of the possible effects of the land-use changes (as done in Lacombe et al. (2008)). A statistical assessment quantifying change and/or trend significance is also missing (cf. Lacombe et al. (2016) for an example).

Thank you for your comments. For period of 1980-2009, we just used their measured and long-term daily meteorological data of the study area to drive the validated model. There was only one variable (LUC or vegetation) to analyze its impacts on streamflow quantitatively. So the soil data, DEM and meteorological data are all same. The figures of annual flow, rainfall and runoff coefficients for 3 regions of Fig. 2 in the study area are added as Fig. 6. The annual average precipitation over the region was calculated using Thiessen polygon method of ArcGIS 9.3, which divided the basin and gave the

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weight of each meteorological station according to its control area (Fig. 6 (a)). And the regional annual average runoff coefficients were 0.13, 0.27 and 0.16 for figure 6 (a), (b) and (c) in turn.

Fig.6 The time-series of precipitation, annual streamflow and runoff coefficients for the study area

(3) There is an overall lack of clarity in the writing. The methods used should be explained in more details and with more precision. Figure 1 shows 4 types of treatments for water and soil conservation that occurred in the study area: forestation, terraces, grass and dam. The hydrological impact assessment focuses exclusively on forestation while the 3 others are completely ignored in the analysis. They certainly have altered river flows too. How to account for their effect in the SWAT model? The maps of the study area (figures 2 and 3) do not show where these technics have been implemented. Splitting the section “Results and discussion” into two distinctive sections “Results” and “Discussion” would certainly help the authors clarifying their scientific demonstration. As it stands, in many places, actual results are juxtaposed with results of previous research which are not referenced.

Thank you for your criticism. We have revised the manuscript carefully and add more details to make the writing clarify and avoid possible grammar or syntax error. There were measures of forestation, terrace, grass and dam for soil and water conservation. According to Fig.1, we could see the soil and water conservation measures were mainly implemented in the study area after the 1980s in study area. Hence we choose 1960-1969 and 1970-1979 for the model calibration and validation respectively. For period of 1980-2009, we just used their measured and long-term daily meteorological data in the study area to drive the validated model for the designed hydrological experiments. Measures of soil and water conservation are classified according to LUC types, which are divided into six types and further 25 subtypes. And the six types included forest, pasture, cropland, water body, residential area and bare. For example, the terrace is treated as Agricultural land with different slope. The impacts of terrace and dam on

streamflow are clear. But the impacts of vegetation on streamflow are controversial and complicated and results are different among different basins. We also analyzed the impact of grass on streamflow monthly. The result was similar with forest and its impact on stream was smaller than that. So the forest was selected to analyze in detail.

Detailed comments:

(1) The title should be improved. Currently, it says that LUCC is impacted by the SWAT model.

We changed the title to be "Impact of LUCC on Streamflow Based on the SWAT Model over the Wei River Basin on the Loess Plateau of China"

(2)Abstract: in line 29, it is mentioned that SWAT is applied to the upper and middle reach of the Wei River Basin. It is not clear what is the role of the hydrological station at the outlet of the lower reach.

Thank you for your suggestion. The Linjiacun, Weijiabu and Xianyang hydrological stations are used in our study (Fig. 2). Linjiacun station locates at the control section of the upstream and Xianyang station is the control station of middle reaches (line 135-136). And Weijiabu station locates between them. The hydrological stations of downstream or the outlet of Wei River were not in our study area. Three regions of different colors in Fig. 2 are divided by 3 hydrological stations of upper and middle reaches.

(3) Introduction: Line 46: a/ the location of the Grain for Green project is missing. b/ Which trees are used for the reforestation? This information is important because, depending on the trees (e.g. deciduous or not), their effect on seasonal flow may be different. c/ the mode of forestation is also primordial when assessing hydrological impacts. For exam-ple, natural forest regrowth or tree plantation can have opposite hydrological effects, depending on how the soil is altered. (cf. Lacombe et al. 2016). The authors should provide more details on the type of forestation.

Thank you for your suggestion. The Grain for Green project involves most area of China, including 1897 counties of 25 provinces (autonomous regions and municipalities), which covers our study area entirely. When the LUCC data are classified and re classified in SWAT model, the tree types are summarized as Range-Brush (RNGB), Forest-Mixed (FRST) and Forest-Deciduous (FRSD). Different types have different hydrological responses for their leaf, roots and so on. We also analyzed the streamflow generation of the main types of forest (RNGB, FRST and FRSD) in study area further. Results showed that the streamflow yield of FRST and FRSD were about 1.20 and 1.60 times of that of RNGB respectively. In Part 2 and 4.1, the forest included all these types, while for the hydrological experiments (part 4.2 and 4.3) the agricultural land was converted into Forest-Mixed (FRST) only.

(4) Lines 62-65 do not provide much information, saying that streamflow can increase whether the vegetation increases or decreases. Too many references here, should be split in two groups (case studies with vegetation increase and case studies with vegetation decrease).

Done! Thank you for your comments. (Line 64-68).

(5) Line 73-75. I don't think that catchment size is the primary control influencing the direction of flow change following land-use change. It is more a question of trade-off between modified infiltration rate and evapotranspiration rate which depends on soil structure, surface properties, depth, slope, vegetation species, etc...

Thank you for your suggestion. We agree with the referee on that point. Some of them thought it was probably the large amount of transpiration water played the main function in hydrological process when the watershed was smaller. And some thought that the different impacts of area probably because the forest of larger watershed could increase precipitation and forest was also conducive to the infiltration of water, which increased the proportion of the underground flow of streamflow in forest region (Line 77-81).

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(6) Lines 79-82. The explanation lacks clarity. Again, latitude may indirectly control the hydrological impact of land-use change, but this is certainly not the primary key player. Thank you for your suggestion. More details are used to explain this. Huang (1982) analyzed Soviet research results found that 48% runoff coefficients increased, 32% has no change, and 20% decreased with watershed forest increasing. The increased regions were located at high latitude and humid areas. Under this condition, the total evaporation in wooded areas and woodless area are equal. The speculation was that snow may be blown away or to wooded areas from woodless area, which could enhance the coefficient of streamflow but these factors would be weaker over low to middle latitude than that in high latitude.(Line 87-91)

(7) Line 89: it is not clear if 43% corresponds to the total treated area included in the Wei Basin or if 43% of treated areas corresponds to afforestation.

Thank you for your suggestion. It is “more than 43% of the total treated area was the forestation in the main stream of Wei River basin”. (Line 101)

(8) Line 90: This statement should be supported by a figure showing the time series of actual annual flow (cf. main comments).

Thank you for your suggestion. The figure of actual annual flow has been added (Fig.6).

(9) Lines 91-92: “streamflow” and “observed annual streamflow”. Are you referring to the same variable? Please keep using the same wording when referring to the same variable.

Thank you for your suggestion. Done! (Line 104)

(10) Lines 93-95. Description of geology should be included in the section “study area”. Thank you for your suggestion.

(11) Line 96: “And that drying layer is in great water deficit”. Why? Reference required. Thank you for your suggestion. A dried soil layer is generally formed in the soil profile

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at a particular depth owing to serious soil desiccation in water-limited ecosystems. The residual maximum likelihood analysis demonstrated that land use, rainfall, soil type and slope gradient had a significant impact on dried soil layer thickness, while only land use, rainfall, and soil type influenced the dried soil layer depth of formation significantly. (Line 109-111)

References: Wang Y., Shao M., Shao H.: A preliminary investigation of the dynamic characteristics of dried soil layers on the Loess Plateau of China, Journal of Hydrology, 381, 9-17, 2010 a. Wang Y., Shao M., Liu Z.: Large-scale spatial variability of dried soil layers and related factors across the entire Loess Plateau of China, Geoderma, 159, 99-108, 2010 b.

(12) Lines 95 to 103: The explanations of the contrasting hydrological behaviours between the “earth-rock mountain landscape” and the Loess Plateau are not clear and not convincing. You did not mention the possible role of slope which is very different between the two types of landscape.

Thank you for your suggestion. Slope is one of the impact factors and it is also a significant impact on dried soil layer thickness (Line 109-111, Wang, 2010a). And for Loess Plateau, which also has lots of mountains, its infiltration water flowing into river is related to slope indeed, while the amount is smaller than that generated from earth-rock mountain landscape.

Study Area

(13) Lines 117-118: need to explain what the units provided define exactly.

Thank you for your suggestion. It may be clear if the sentence is revised as “We choose basin of the upper and middle reaches ($4.68 \times 10^4 \text{ km}^2$) of the Wei River basin ($103.97^\circ\text{E} \sim 108.75^\circ\text{E}$, $33.69^\circ\text{N} \sim 36.20^\circ\text{N}$, $13.48 \times 10^4 \text{ km}^2$). ”. (Line 132-133)

(14) Line 132: MODIS ?

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Thank you for your suggestion. Done! (Line 147)

(15) Line 134: cannot see the six types of LUCC in figure 3.

Thank you for your suggestion. There are more details about legend of Fig. 3. Figure 3 is preliminary classification results of the 25 subtypes of LUCC types. And then it is classified to the six types including forest, pasture, cropland, water bodies, residential areas and the bare. The corresponding relations between Fig. 3 and these six types are: “ The forest type includes Range-Brush (RNGB), Forest-Mixed (FRST), Forest-Deciduous (FRSD), Pine (PINE) and Forest-Evergreen (FRSE); “ The pasture type includes Pasture (PAST), Winter Pasture (WPAS) and Range-Grasses (RNGE); “ The cropland means Agricultural Land (AGRL); “ Water includes water (WATR) and Wetlands-Mixed (WETL); “ The residential areas include area of Residential-High Density (URHD) and Residential-Medium Density (URMD); “ The code of bare type is BARE. (Line 151-156)

(16) Lines 136-137: Forest area increased by 0.81% only. It is hardly believable that the hydrological impact quantified later (line 270), (annual average reduction of 94 million m³) was caused by this very minor change.

Thank you for your suggestion. The annual streamflow of 94 million is equal to 2.0 mm/yr for study area, which is the average result of annual streamflow decreased during 20 years. And the average annual streamflow decreased 0.62 mm for all 30 years (1980-2009). These results are in ranges of existing research result also. (Line 299)

(17) Line 141: unlike what is written, the soil characteristics are not indicated on the map, (only the names of the soil types are provided).

Thank you for your suggestion. This map means “the soil data map”, which is a vector data including much information and did not just Fig. 4 (a). The detailed soil characteristics can be found from data base we offered. There are 83 types of soil in study area

and the types are classed according to soil composition, soil particle size and so on. There are some soil characteristics of HRU 1 in study area for example.

Land use: AGRL Soil Name: QSHMT Depth [mm]: 120.00 620.00 1280.00 Bulk Density Moist [g/cc]: 1.33 1.46 1.50 Ave. AW Incl. Rock Frag: 0.19 0.18 0.17 Ksat. (est.) [mm/hr]: 16.58 4.93 3.73 Organic Carbon [weight %]: 2.80 1.00 0.50 Clay [weight %]: 23.00 24.00 25.00 Silt [weight %]: 62.00 60.00 58.00 Sand [weight %]: 15.00 16.00 17.00 Rock Fragments [vol. %]: 0.00 0.00 0.00 Soil Albedo (Moist) : 0.16 0.16 0.16 Erosion K : 0.34 0.40 0.34 Salinity (EC, Form 5) : 0.00 0.00 0.00

(18) Line 145: meaning of HRUs ?

Thank you for your suggestion. HRUs are Hydrological response units and the full name has been added. (Line 166)

(19) Lines 154, 239 and 264-265: avoid “and so on”.

Thank you for your suggestion. Done!

(20) Line 160: cf. advices provided in my main comments.

Thank you for your suggestion. Done!

(21) Line 179: need to provide much more information on the input data used to run SWAT.

Thank you for your suggestion. The input data refers to data involved in last sentence “It is forced with meteorological data and input with soil properties, topography, land use, and land management practices in the catchment”. (Line 198-199)

(22) Lines 185-186: what is an “extraction threshold”?

Thank you for your suggestion. The extraction threshold area defines the minimum drainage area required to form the origin of a stream (Line 208-209). The user has the ability to set the minimum size of the subbasins. This function plays an important

role in determining the detail of the stream network and the size and number of sub-watersheds. (Arcswat interface for SWAT 2009 User's guide, 2010).

(23) Line 190: if subdivided into 1 HRU, then it is not subdivided. Please clarify.

Thank you for your suggestion. Delineate the watershed into subbasins using Digital Elevation Model (DEM) data and define the HRUs are key and necessary procedures for SWAT model building. Each watershed is first divided into subbasins and then in hydrologic response units (HRUs) based on the land use and soil distributions. And they have different functions. When a watershed is divided into subbasins, lots of information is loaded into the model from five sections: DEM setup, stream definition, outlet and inlet definition, watershed outlet selection and definition and subbasin parameters. And HRU analysis allows users to load land use and soil layers into the model, evaluate slope characteristics, and determine the land use/soil/lope class combinations and distributions for the delineated watershed and each subbasin. (Arcswat interface for SWAT 2009 User's guide, 2010).

(24) Page 11: many parameters and initial values used to calibrate the SWAT model were issued from previous research and experiments (e.g. lines 219: "derived from simulated rainfall experiments", 228: "We have done some research", 230: "Based on the experiments", 234: "were gotten based on experiments"). No references and no explanations are provided. We need more details to understand what has been done.

Thank you for your suggestion. Done!

(25) Lines 237: It is not clear how the authors have accounted for the "management operation of forest" which affect "leaf area index [...], plant biomass [...], age of trees". Need to provide some explanations here. Which management operations are accounted in the model and how do they affect the variables listed here?

Thank you for your suggestion. SWAT model can simulate 15 different types of management operations. The primary file used to summarize the land and water manage-

ment practices taking place is the HRU management file (.mgt). This file contains input data for planting, harvest, irrigation applications, nutrient applications, pesticide applications, and tillage operations. In our modeling process, the agricultural land includes operations: planting/ beginning of growing season, auto fertilization initialization, harvest and kill operation. The forest just includes planting/ beginning of growing season. The planting/ beginning of growing season operation initialize the growth of a specific land cover/ plant type in the HRU. For example:

âŠ• HRU 1 Land use: AGRL Operation Schedule: Operation Schedule: 0.150 1 1 967.69930 0.00 0.00000 0.00 0.00 0.00 0.160 11 1 0.75000 0.00 0.00000 0.00 0.00 1.200 5 0.00000 The first line is the planting/ beginning of growing season operation. The parameters of the first four numbers are HUSC, MGT_OP, PLANT_ID, HEAT UNITS in turn. HUSC is the timing of planting operation, which is the fraction of total base zero heat units at which operation takes place. MGT_OP is operation code. MGT_OP=1 is for plant operation. PLANT_ID is plant/ land cover code from crop.dat. PLANT_ID=1 means that the crop is warm season annual legume. For this crop type, the root depth varies during growing season due to root growth and heat unit theory is used to regulate the growth cycle of plants. HEAT UNITS is the total heat units for cover/plant to reach maturity. Temperature is one of the most important factors governing plant growth. For any plant, a minimum or base temperature must be reached before any growth will take place. Above the base temperature the more rapid the growth rate of the plant. Once the optimum temperature is exceeded the growth rate will begin to slow until a maximum temperature is reached at which growth ceases. The heat unit theory postulates that plants have heat requirements that can be quantified and linked to time to maturity. For example, assume sweet peas are growing with a base temperature of 5 oC. If the mean temperature on a given day is 20 oC, the heat units accumulated on that day are $20 - 5 = 15$ heat units. MGT_OP=5 is for harvest and kill operation plant operation. This operation harvests the portion of the plant designated as yield, removes the yield from the HRU and converts the remaining plant biomass to residue on the soil surface. The harvest and kill operation stops plant

growth in the HRU. The fraction of biomass specified in the land cover's harvest index is removed from HRU as yield.

âŠª HRU 307 Land use: FRST Operation Schedule: 0.150 1 6 50 1043.40000 5.00 1000.00000 0.00 0.00 0.00

The parameters of the first seven numbers are HUSC, MGT_OP, PLANT_ID, CURYR_MAT, HEAT_UNITS, LAT_INIT, BIO_INIT in turn. The HUSC and MGT_OP are the same with AGRL. PLANT_ID=6 means that the crop is perennial which root depth always equal to the maximum allowed for the plant species and soil and plant goes dormant when daylength is less than the threshold day length. CURYR_MAT is the current age of trees (years). LAT_INIT is the initial leaf area index. This variable is used only for covers/ plants which are transplanted rather than established from seeds. LAI is the leaf area index of the canopy. The plant canopy can significantly affect infiltration, surface runoff and evaporation. Canopy storage is the water intercepted by vegetative surface where it is held and made available for evaporation. When precipitation falls on any given day, the canopy storage is filled before any water is allowed to reach ground. Potential soil water evaporation and plant transpiration are estimated as a function of potential evapotranspiration and LAI. The leaf area index (LAI) for the reference crop is estimated using an equation developed by Allen et al. (1989) to calculate LAI as a function of canopy height. For trees, the fraction of potential heat units accumulated for the plant on a given day in the growing season, the fraction of growing season, the number of years for the tree species to reach development. BIO_INIT is the initial dry weight biomass (kg/ha). This variable is used only for covers/ plants which are transplanted rather than established from seeds. The potential increase in plant biomass on a given day is a function of intercepted energy and the plant's efficiency in converting energy to biomass. Energy interception is estimated as a function of solar radiation and the plant's LAI.

Results and discussions

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(26) Line 253: It is not clear if the model efficiencies provided correspond to an average for each hydrological unit or for the whole basin.

Thank you for your suggestion. They were corresponding statistic results of Fig. 7 (The time-series graphs of calculated vs. observed values during calibration period and verification period for hydrological stations) for each hydrological station. (Line 275)

(27) Lines 257, 258: unlike what is written, the trend is not obvious in fig. 6. It would be clearer to redraw the figure at the monthly and annual time steps to visualize possible trends over years.

Thank you for your suggestion. The monthly time-series graph of calculated vs. observed values during calibration period and verification period for hydrological stations is as follows.

Fig. 1.1 The monthly time-series graphs of calculated vs. observed values during calibration period and verification period for hydrological stations

(28) Line 269: it is not clear what is the 20-year period referred here. Calibration and validation periods are 10 years long and simulation period include 30 years. Further explanations are required. Line 270: there are 3 problems here. 1/ it is not clear in which catchment the hydrological change (annual average reduction of 94 million m3) was assessed, upper or middle ?. b/ this hydrological change should be translated into millimeters of runoff reduction to assess its magnitude and significance. c/ the text indicates that this change is caused by forestation. Indeed, it only reflects the change in the model parameters between the calibration/validation and the simulation periods. But, as already indicated, it does not reflect the actual changes that occurred in the catchment.

Thank you for your suggestion. We have revised this part (Line 298-299). It is 20 years in 30 simulation years, which annual streamflow decreased. In other 10 years,

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the streamflow did not decrease. (a) It changed in the study area (upper and middle reaches of the Wei River basin). (b) The annual average reduction was 2.0 mm/yr for these years in study area (Li). (c) The text indicates that the change is caused by LUCC and hydrological conditions. Because the LUCC involves too many types of land uses, we then designed the experiments for forest changing only to study its impact. Because under the same hydrological condition, the streamflow reduced in most years and increased in other years, 30-year average of the streamflow for forest and agricultural land were taken, respectively to reduce influence of meteorological conditions and isolate the impact of the LUCC on streamflow.

(29) Line 273: reference required when referring to previous experiments.

Thank you for your suggestion. Done!

(30) Lines 278-279: “30-year average of the streamflow for forest and agricultural land weretaken”. Please explain what was done exactly here. Are you referring to the two sets of simulated flow described in lines 263-267? or different hydrological units with agricultural land or forest cover for a given period?

Thank you for your suggestion. The 30-year (1980-2009) average values of the streamflow for forest and agricultural land were averaged respectively. (Line 308-309)

(31) Lines 291-294. This paragraph is about method and should be moved in the appropriate section. It is referring to 3 regions. Which ones? Three different approaches re described to define the LUCC scenarios but the results of each approach are not resented. It seems that figures 8, 10 and 12 only present results for approach 1. Thank you for your suggestion. The 3 regions were divided by 3 Linjiacun, Weijiabu and Xi- anyang hydrological stations (three different color regions with number) (Line 331-332). They were 3 control conditions when the land use converted from agricultural land to forest. The second and third conditions were considered as much as possible to reduce impacts of other factors.

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(32) Line 306: the authors indicate that the actual change in forest cover calculated using the land-use maps displayed in figure 3 (0.8% increase) would lead to less than 1% change in streamflow. I agree with this realistic statement but: is it consistent with the hydrological change quantified in line 270?

Thank you for your suggestion. Line 306 is the result of conversion of agricultural land to forest on streamflow. Line 270 is the result of LUCC changes on streamflow, which involves many types of land use conversion measures and is a balanced result among these measures. So the changes of streamflow, surface runoff, soil flow and baseflow between agricultural land and forest were singled out (Fig. 9 The changes of 30-year (1980-2009) averages of streamflow, surface runoff, soil flow and baseflow between agricultural land and forest.). We can see the impacts are consistent.

(33) Lines 314-325. the authors explain differences in hydrological behaviour of the Loess Plateau and earth-rock mountain, based on other publications, but this paragraph is not linked to the result of the study. The authors need to evidence how these distinctive hydrological behaviours influence their results.

Thank you for your suggestion. As suggested, we revised the whole manuscript carefully and add more details to make it clean.

Figures

(34) Fig. 1: Areas under different treatments are expressed in 104 hm² (i.e. squared hectometers?). This is an atypical unit which is different from the unit used for the study area in the text (104 km²). All areas should be provided in same unit to allow easier comparison. It would be clearer to provide the percentage area so that we anticipate the possible effect of the land treatment on the catchment hydrology.

Thank you for your suggestion. Figure 1 is revised as suggestion.

Fig.1

(35) Fig.2. What is the meaning of all small numbers written on the map of the study

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area? If they correspond to hydrological units, it is surprising to see numbers in the downstream part which is not included in the study area.

Thank you for your suggestion. The numbers of Fig. 2 are serial number of subbasins/HRUs (Line 208). All numbered area is study area. Linjiacun station locates at the control section of the upstream and Xianyang station is the control station of middle reaches (Line 133-135). And the upper and middle reaches of the Wei River basin is the study area.

(36) Fig. 6. The scale on the X axis is too big: we cannot see the details in the daily flow variations and in the matching between observed and simulated flow. The figure should be bigger or all panels (calibration and verification should be put in the same column to allow larger size.

Thank you for your suggestion. It is more clearly indeed as suggestion (Fig. 7).

Fig. 7

(37) Fig. 9: What is the meaning of “corresponding proportional change rate”?

Thank you for your suggestion. It is the change rate of streamflow at the Linjiacun, Weijiabu and Xianyang stations correspondingly. We have revised the figure (Fig.11).

References:

Lacombe G, Cappelaere B, Leduc C. 2008. Hydrological impact of water and soil conservation works in the Merguellil catchment of central Tunisia. *Journal of Hydrology*. 359: 210-224. Lacombe G, Ribolzi O, de Rouw A, Pierret A, Latsachak K, Silvera N, Pham Dinh R, Orange D, Janeau JL, Soullileuth B, Robain H, Taccoen A, Sengphaathith P, Mouche E, Sengtaheuanghoung O, Tran Duc T, Valentin C. 2016. Contradictory hydrological impacts of afforestation in the humid tropics evidenced by long-term field monitoring and simulation modelling. *Hydrology and Earth System Sciences*. 20:2691-2704.

Thank you for your recommendations. The references have been cited (Line 53-54, line 84).

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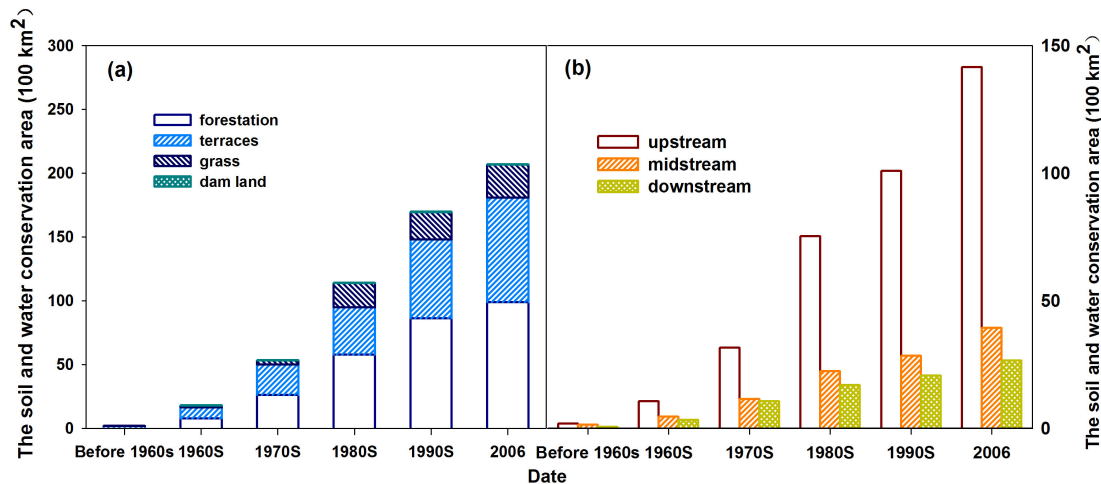


Fig. 1. Fig. 1 The development of soil and water conservation measures in the main stream basin of Wei River over last 50 years.

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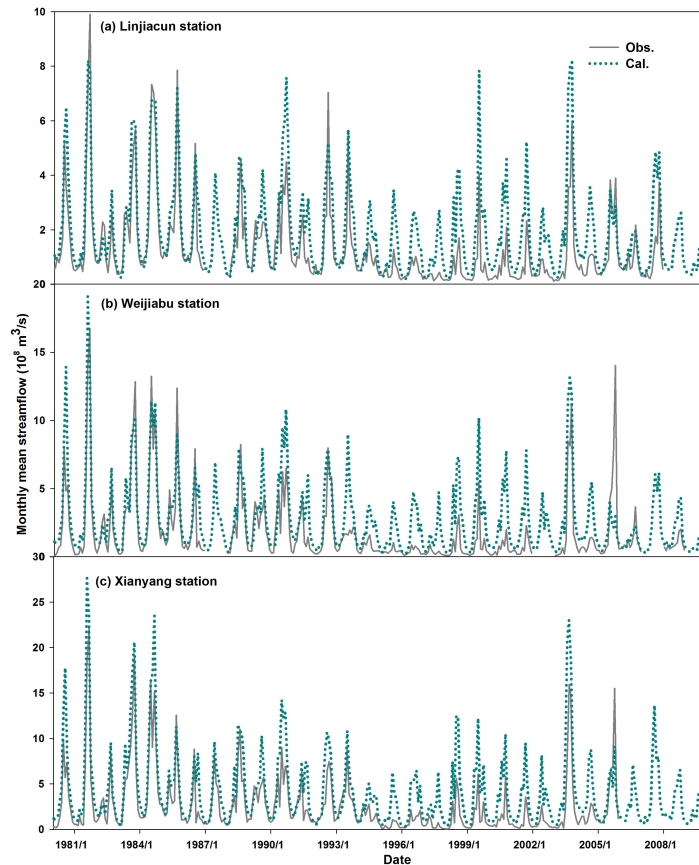



Fig. 2. Fig. 8 The time-series graphs of calculated vs. observed streamflow during 1980-2009 for hydrological stations.

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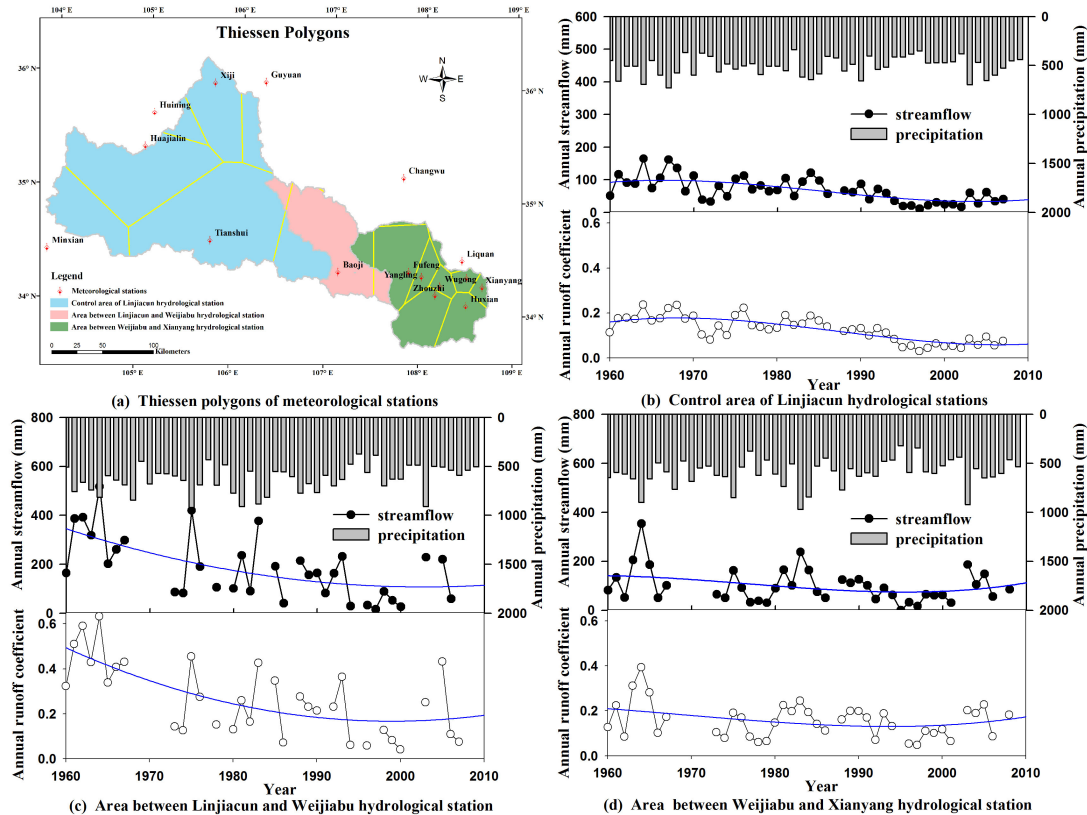


Fig. 3. Fig.6 The time-series of precipitation, annual streamflow and runoff coefficients for the study area

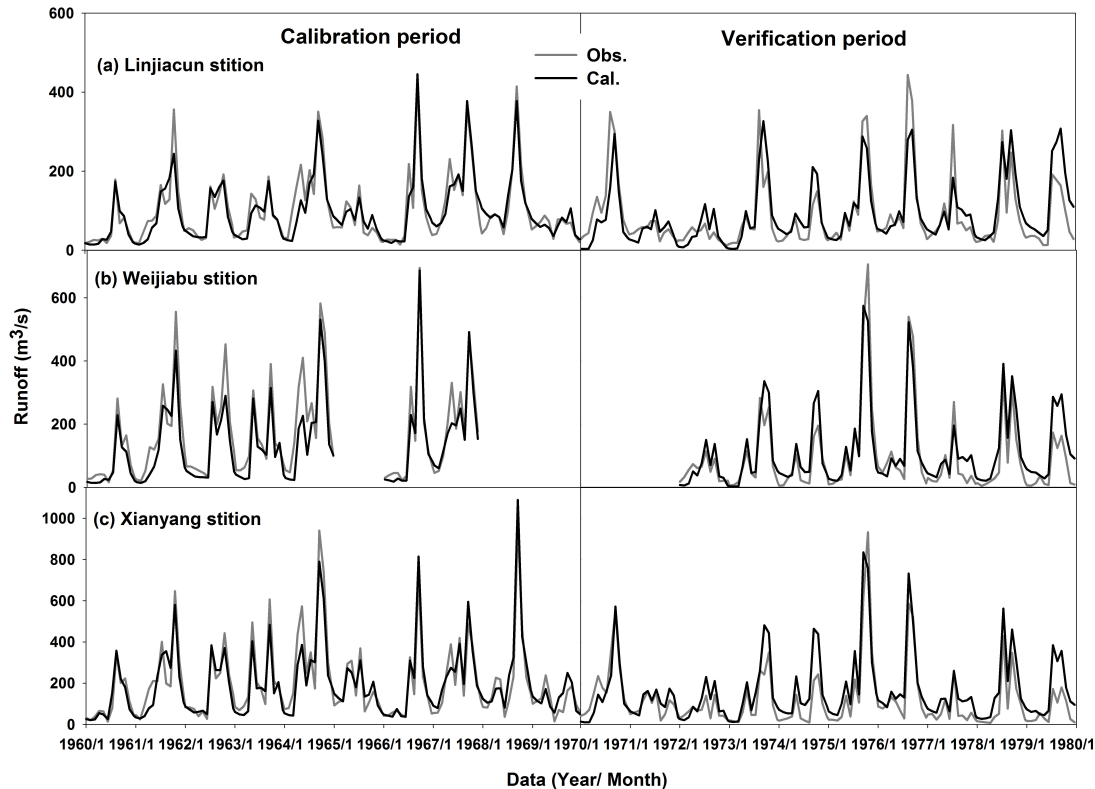


Fig. 4. Fig. 1.1 The monthly time-series graphs of calculated vs. observed values during calibration period and verification period for hydrological stations

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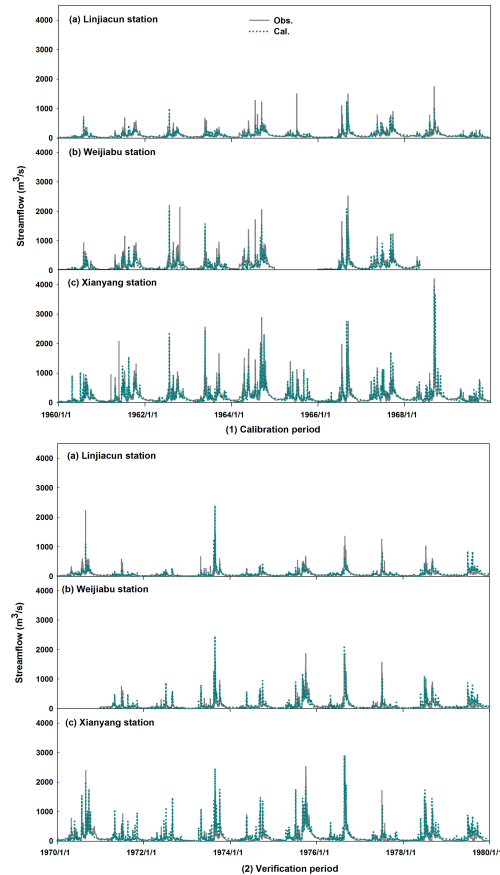


Fig. 5. Fig. 7 The time-series graphs of calculated vs. observed values during calibration period and verification period for hydrological stations.

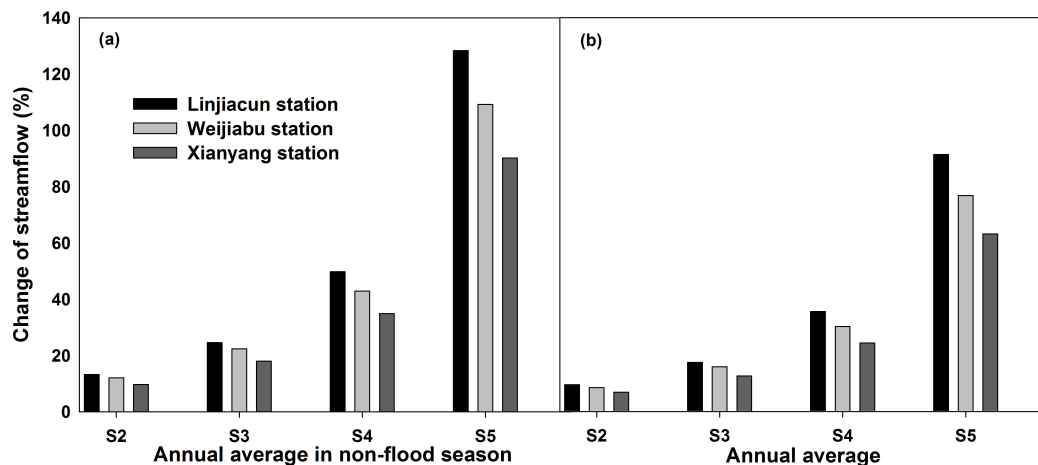


Fig. 6. Fig. 11 The corresponding proportional change rate of streamflow at Linjiacun, Weijiabu and Xianyang station for annual average and annual average in non-flood season.

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