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Long-term forecasts of water availability in small foothill rivers of Uzbekistan

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Long-term forecasts of water availability in small foothill rivers of Uzbekistan

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Abstract. This article presents the obtained results of the application of integrated hydrological models. Observed data and simulations diverge especially during the period when the maximum flow rates are observed. This is mainly due to the parameters of climate and soil, which are taken into account when checking sensitivity to unknown values. To increase the accuracy of the results, the selection method is used, and the analysis of the results. Outcomes show that the correlation coefficient is more than 60%. However, it is possible to enhance this connection. For this, it is necessary to change the sensitivity parameters to unknown values several times and restart the models. The simulation results of the high water period are smoother than the observed values. It refers, to maximum water discharges; even integrated models face difficulties in taking account of all the factors that form the surface runoff. Therefore, the hydrologic models that are applying nowadays have to be improved and developed for better outcomes.

1. Introduction

The Gissar ridge towering above the Surkhandarya river valley in the north is the highest in the basin; its individual peaks slightly exceed the 4,500 m above mean sea level. There is slight glaciation on the slopes, and the surface runoff consists of at least 70% of the total surface inflow into the lowland area of the basin. The Surkhandarya River (length 196 km) is formed by the confluence of the Tupalang and Karatag rivers [1], of which the first is the most auriferous (average discharge at the exit of the mountains Tupalang River 52 m^3/s, Karatag 23 m^3/s). Tupalang river's total length is 112 km, F - 2200 km^2 [2].

The average basin height is 2546 m. Heights of more than 4000 m occupy only 3.1% of the total area, and heights exceeding 3500 m – 15.4%. Surface runoff of the river flow is formed due to the melting of seasonal snows and snowfields, the participation of eternal snows, and even fewer glaciers in the river flow are negligible. Tupalang belongs to the rivers of snow-glacier feeding with the corresponding character of the intra-annual distribution of runoff [3]. The average runoff module of the Tupalang River is 23.6 l/s km^2. The coefficient of variation of the annual runoff C_v is 0.18, which indicates the comparative stability of the annual runoff of the river, given the nature of its nourishment type [4]. The regulated base flow of the Tupalang River is rather weak (regulation is the participation or share of groundwater in the formation of surface runoff). Runoff for October-February is only 10.6% per annum, and the coefficient of intra-annual flow unevenness is 0.40. The low regulation of runoff is explained by the wide distribution of igneous, mainly intrusive rocks in its catchment (65.3%) [5].

The hydrological modeling which is applied in this research, the SWIM model was first described in 1989, based on the structure of another model - the Soil and Water Assessment Tool (SWAT) [6]. There are semi-distributed, continuous, eco-hydrological models of a conceptual type. Besides, the model requires average daily data. The SWIM model simulates water discharge, water quality parameters, components of the hydrological cycle, and agricultural products with daily increments [11].

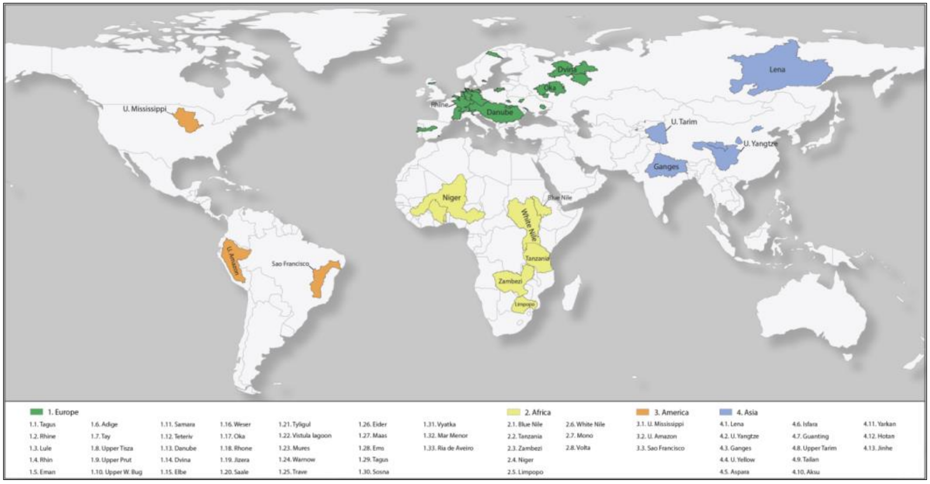


Figure 1. Several river basins of the world where SWIM model is already applied to solve hydrological issues

In Figure 1, you can see the classes in the colored background that the SWIM model worked successfully. One of them is the Asia region (Figure 2) which has several river basins displayed.

🟦 4. Asia

4.1. Lena
4.2. U. Yangtze
4.3. Ganges
4.4. U. Yellow
4.5. Aspara
4.6. Isfara
4.7. Guanting
4.8. Upper Tarim
4.9. Tailan
4.10. Aksu
4.11. Yarkan
4.12. Hotan
4.13. Jinhe

Figure 2. River basins of Asia where the model applied

2. Methods

GIS GRASS was used for river modeling supported by the SWIM hydrological model [7]. For modeling, we prepared in tabular form climatic data, in a cartographic form of land use, soil and satellite images SRTM DEM 90 m (http://srtm.csi.cgiar.org/) [8] and the point of hydrological posts, which includes the coordinates of the hydrological stations (shape file). The water discharge data of this gauging station can be ordered through the site– bafg.de/GRDC/EN/01_GRDC/13_dtbse/database_node.html) [9].

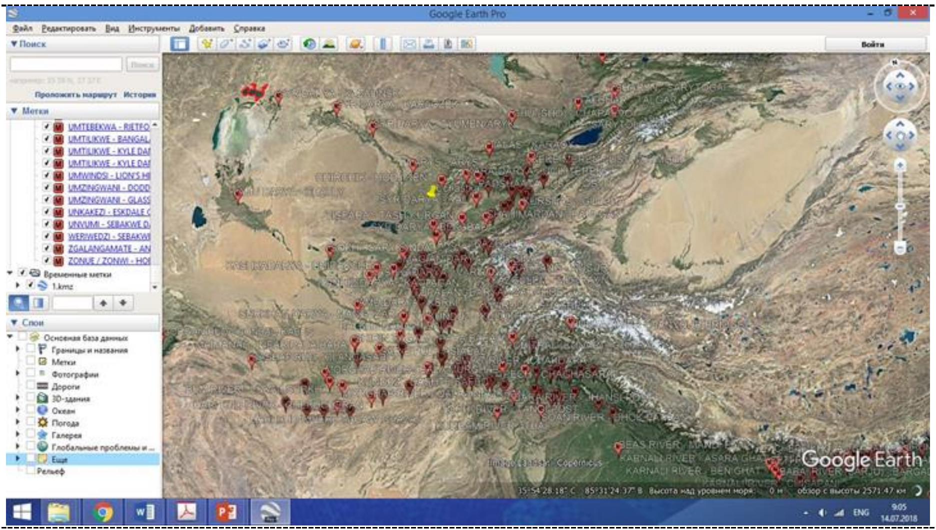
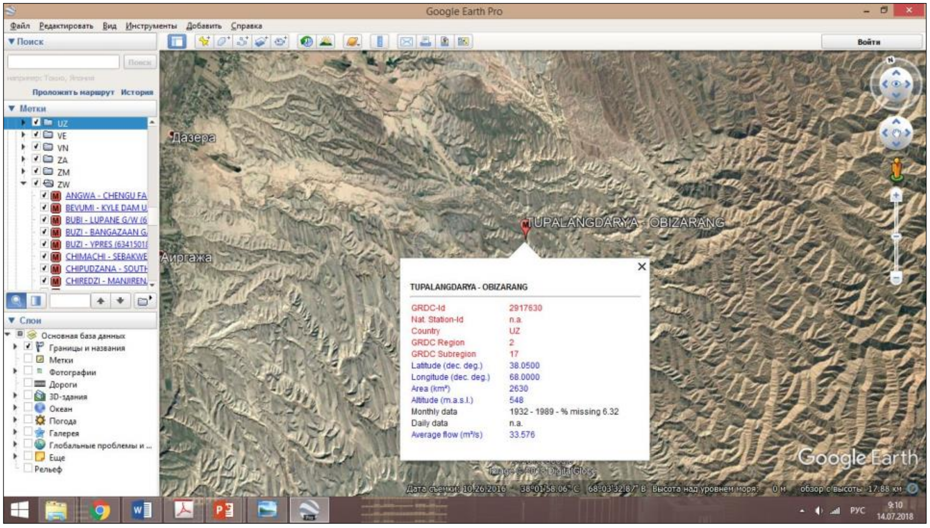


Figure 3. Geolocation of gauging stations

In the focusing area there are two hydrological stations: Obizarang and Zarchup:



TUPALANGDARYA - OBIZARANG

GRDC-Id	2917630
Nat. Station-Id	n.a.
Country	UZ
GRDC Region	2
GRDC Subregion	17
Latitude (dec. deg.)	38.0500
Longitude (dec. deg.)	68.0000
Area (km²)	2630
Altitude (m.a.s.l.)	548
Monthly data	1932 - 1989 - % missing 6.32
Daily data	n.a.
Average flow (m³/s)	33.576

Figure 4. Gauging station Obizarang (Data on water discharge from 1932 to 1989 missing data 6.32%)

After that, we prepared the input data for the SWIM model, since the data is Sub-basin, gauging stations, and the structure of the river network. Then carried out practical exercises, installed the following software:

Installation of GRASS GIS, integration of SWIM
Installation of *R* and *R* Studio
Interpolation of climate data

Preparation, formatting, and reclassification of spatial data, as the soil map (FAO) and land use (Figure 5) (http://www.globallandcover.com/) [10] for 2010.

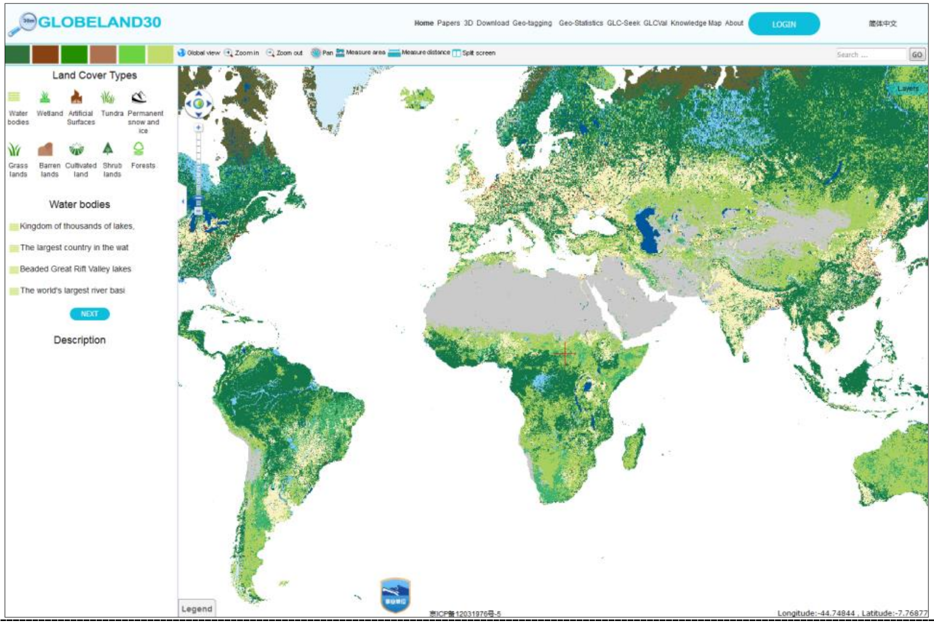
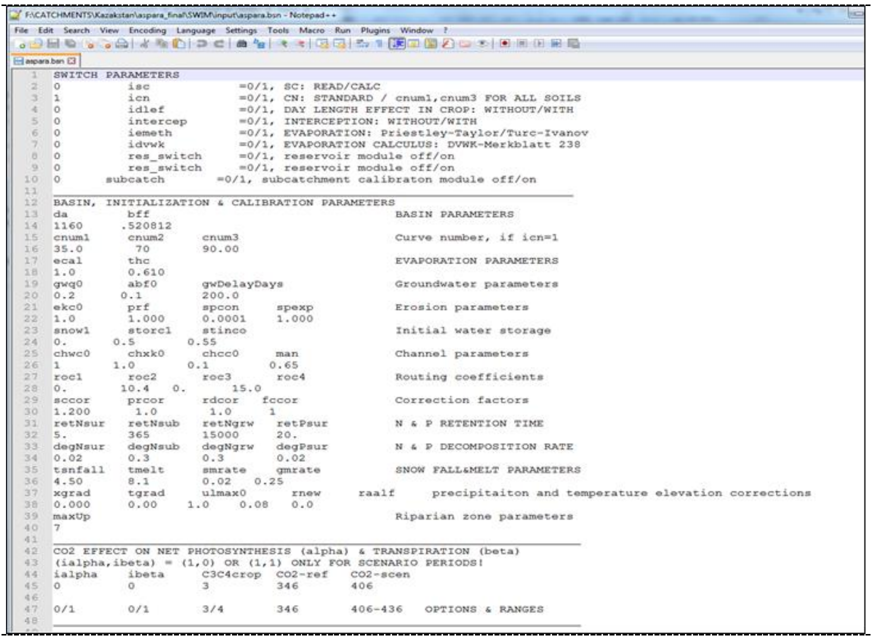


Figure 5. Global land use map for 2010

3. Results and discussion

The main sensitive calibration parameters include indicators as follows, evaporation and radiation, groundwater, reservoir, channel parameters, snow parameters, etc. Besides, changing the sensitivity of the parameters is one of the most important stages in the calibration of the model (Figure 7). For more accuracy and sensitivity of the results in SWIM modeling whole river basin divides into sub-basins, and these partitions into hydrotops respectively. It helps to decrease the errors related to soil properties [12].



```
SWITCH PARAMETERS
0          isc            =0/1, SC: READ/CALC
1          icn            =0/1, CN: STANDARD / cnum1,cnum3 FOR ALL SOILS
0          idlef          =0/1, DAY LENGTH EFFECT IN CROP: WITHOUT/WITH
0          intercep       =0/1, INTERCEPTION: WITHOUT/WITH
0          iemeth         =0/1, EVAPORATION: Priestley-Taylor/Turc-Ivanov
0          idvwk          =0/1, EVAPORATION CALCULUS: DVWK-Merkblatt 238
0          res_switch     =0/1, reservoir module off/on
0          res_switch     =0/1, reservoir module off/on
0       subcatch       =0/1, subcatchment calibraton module off/on
___________________________________________________________________________
BASIN, INITIALIZATION & CALIBRATION PARAMETERS
da         bff                                          BASIN PARAMETERS
1160      .520812
cnum1      cnum2      cnum3                             Curve number, if icn=1
35.0        70        90.00
ecal       thc                                          EVAPORATION PARAMETERS
1.0        0.610
gwq0       abf0       gwDelayDays                       Groundwater parameters
0.2       0.1         200.0
ekc0       prf        spcon      spexp                  Erosion parameters
1.0        1.000      0.0001     1.000
snow1      storc1     stinco                            Initial water storage
0.       0.5        0.55
chwc0      chxk0      chcc0      man                    Channel parameters
1        1.0        0.1         0.65
roc1       roc2       roc3       roc4                   Routing coefficients
0.        10.4   0.      15.0
sccor      prcor      rdcor    fccor                    Correction factors
1.200       1.0        1.0      1
retNsur    retNsub    retNgrw    retPsur                N & P RETENTION TIME
5.         365        15000      20.
degNsur    degNsub    degNgrw    degPsur                N & P DECOMPOSITION RATE
0.02       0.3        0.3        0.02
tsnfall    tmelt      smrate     gmrate                 SNOW FALL&MELT PARAMETERS
4.50       8.1        0.02   0.25
xgrad      tgrad      ulmax0      rnew      raalf     precipitaiton and temperature elevation corrections
0.000      0.00    1.0    0.08    0.0
maxUp                                                   Riparian zone parameters
7
___________________________________________________________________________
CO2 EFFECT ON NET PHOTOSYNTHESIS (alpha) & TRANSPIRATION (beta)
(ialpha,ibeta) = (1,0) OR (1,1) ONLY FOR SCENARIO PERIODS!
ialpha     ibeta      C3C4crop   CO2-ref    CO2-scen
0          0          3          346        406

0/1        0/1        3/4        346        406-436   OPTIONS & RANGES
___________________________________________________________________________
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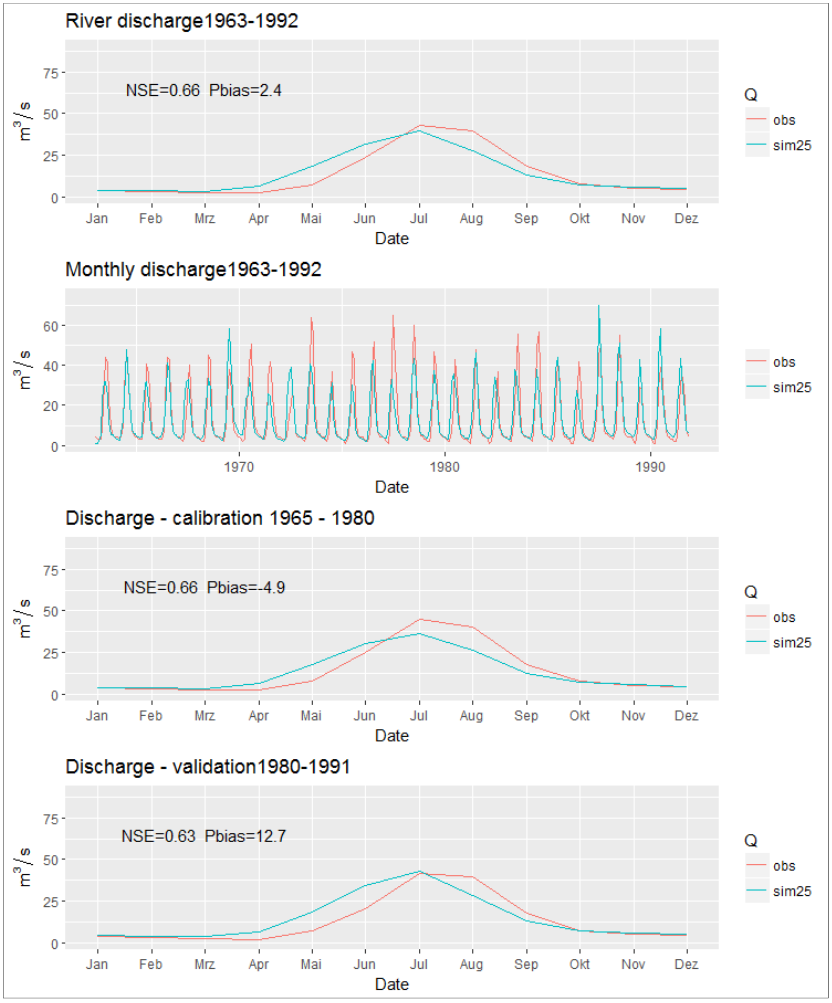
Figure 6. The parameters of sensitivity

After starting the SWIM model, the results must be analyzed; if the results are unsatisfactory, you will have to change the river basin parameters and run the model again. The daily results obtained can be converted to a monthly average and annual average using the programming language R [6]. The picture depicts that in the period of high water phase simulated and observed values are not matching. It occurs due to climate and soil factors which are listed as sensitivity parameters [13, 14, 15].


River discharge1963-1992

Monthly discharge1963-1992

Discharge - calibration 1965 - 1980

Discharge - validation1980-1991

Figure 7. Results of calibration and validation

4. Conclusion

After plotting the data obtained, it can be seen that the observed data and the simulations diverge especially during the period when the maximum costs are observed. This discrepancy is mainly caused by the presence of climate and soil parameters, which are taken into account when testing sensitivity to unknown values. To increase the accuracy of the results, the selection method is used, and the analysis of the results obtained. Also, the results show that the correlation coefficient is more than 60%. However, it is possible to increase this ratio. For this, it is necessary to change the sensitivity parameters several times and restart the models. The results during the flood of the simulation are smoother than the observed values. This means that, at maximum costs, even integrated models cannot all the factors that form the surface runoff.

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