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

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Abstract

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

Material and methods

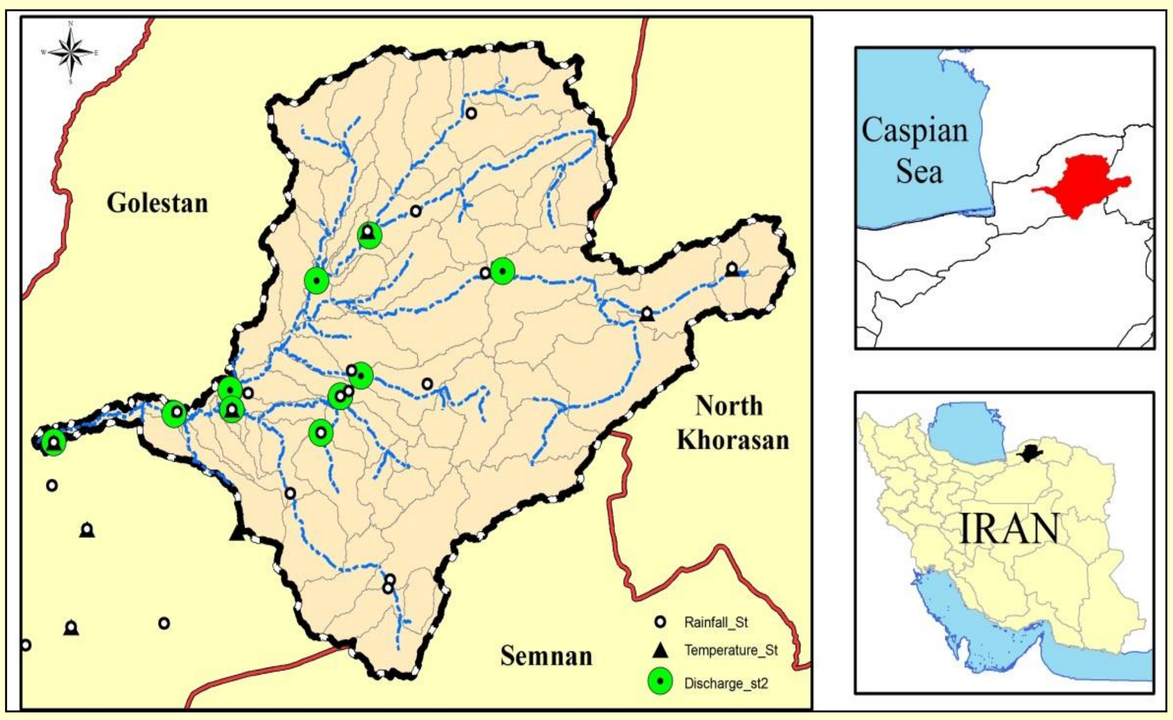

Fig. 1 Location of the Gorganroud basin in Iran.

SWAT Setup

- **land use map was extracted from Landsat satellite images of 2010, with a spatial resolution of 30 m.**
- **Soil map was obtained from the Iranian Ministry of Agriculture with a spatial scale of 1:250,000 .**
- **The DEM at 90m resolution were obtained from the National Cartographic Centre of Iran.**
- **Daily observed climate data including daily precipitation and temperature were obtained for 18 stations from the Iranian Meteorological Organization and the Water Resources Management Organization (WRMO) of Iran.**
- **monthly discharge data from 10 hydrometric stations and a large number of total suspended sediment (TSS) samples for 6 hydrometric stations within the basin from WRMO of Iran.**
- **The climate data from the Climatic Research Unit, University of East Anglia, under 18 scenarios for monthly fields of maximum temperature, minimum temperature, precipitation, and the number of wet days on a 0.5° grid from 2001 to 2100 are provided.**

Results

Table1. Initially selected calibration parameters

Parameter name	Description	Initial range	
		Min	Max
r__CN2.mgt	NRCS runoff curve number for moisture condition II	-0.5	0.5
v__ALPHA_BF.gw	Base flow alpha factor (days)	0	1
v__GW_DELAY.gw	Groundwater delay time (days)	30	450
v__CH_N2.rte	Manning's n value for main channel	0	0.3
v__CH_K2.rte	Effective hydraulic conductivity in the main channel (mm hr 1)	5	130
v__SURLAG.bsn	Surface runoff lag time (days)	1	24
r__SOL_AWC.sol	Soil available water storage capacity (mm H2O/mm soil)	-0.2	0.4
r__SOL_K.sol	Soil conductivity (mm hr 1)	-0.8	0.8
r__SOL_BD.sol	Soil bulk density (g cm 3)	-0.5	0.6
v__SFTMP.bsn	Snowfall temperature (°C)	-5	5
v__SMTMP.bsn	Snowmelt base temperature (°C)	-5	5
v__SMFMX.bsn	Maximum melt rate for snow during the year (mm°C 1 day 1)	0	10
v__SMFMN.bsn	Minimum melt rate for snow during the year (mm°C 1 day 1)	0	10
v__TIMP.bsn	Snow pack temperature lag factor	0.01	1
v__REVAPMN.gw	Threshold depth of water in the shallow aquifer for 'revap' to occur (mm)	0.02	0.2
v__GW_REVAP.gw	Groundwater revap. Coefficient	0	500
v__GWQMN.gw	Threshold depth of water in the shallow aquifer (mm)	0	5000
v__RCHRG_DP.gw	Deep aquifer percolation fraction	0	1
v__ESCO.hru	Soil evaporation compensation factor	0.01	1
v__EPCO.hru	Plant uptake compensation factor	0.01	1
r__OV_N.hru	Manning's n value for overland flow	0	0.8
r__SOL_ALB.sol	Moist soil albedo	-0.5	0.5
v__SLSUBBSN.hru	Average slope length	10	150
v__SHALLST.gw	Initial depth of water in the shallow aquifer	0	1000
v__PRF.bsn	Peak factor for sediment routing channel	0	2
v__SPCON.bsn	Linear re-entrainment parameter for channel sediment routing	0.001	0.01
v__SPEXP.bsn	Exponent of re-entrainment parameter for channel sediment routing	1	1.5
v__CH_COV.rte	Channel cover factor	0	1
v__CH_EROD.rte	Channel erodibility factor	0	0.6
r__USLE_K.sol	USLE soil erodibility factor	-0.8	0.8
r__USLE_C.CROP.DAT	USLE land cover factor	-0.5	0.5

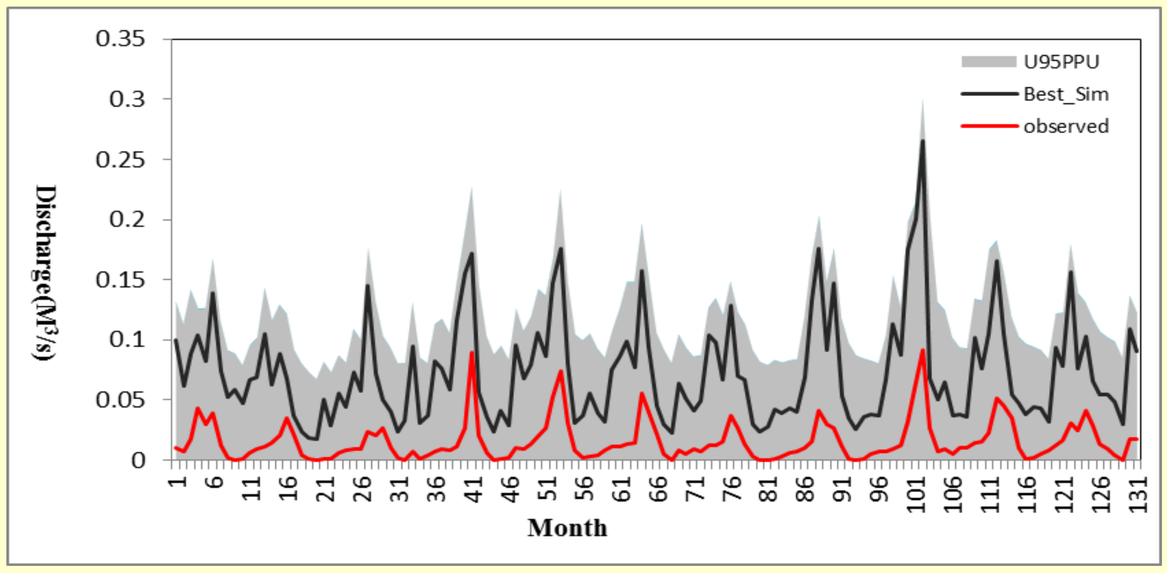

Fig. 2 Result of initial runoff calibration

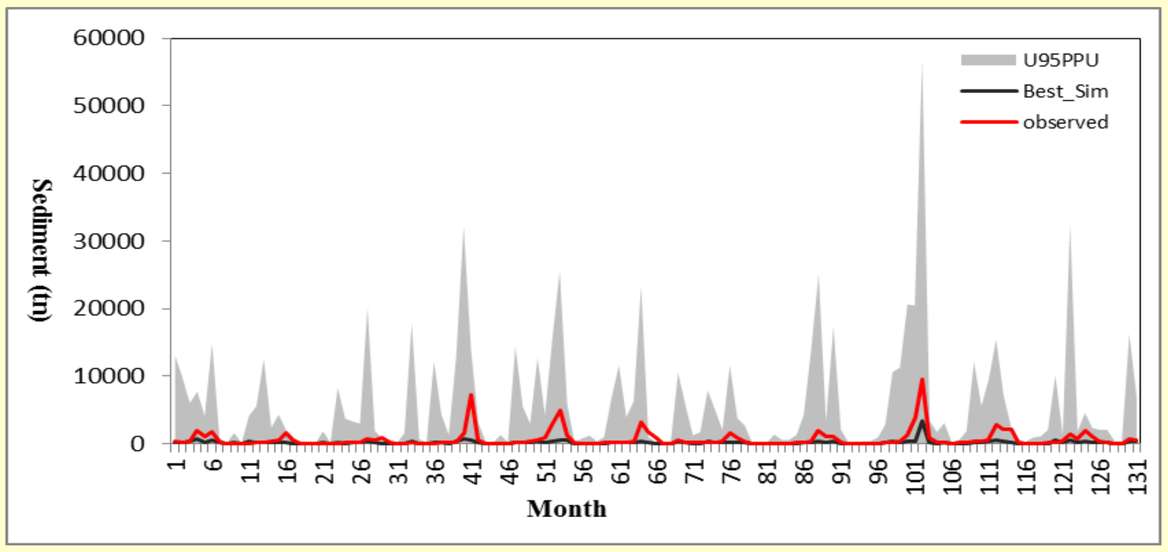

Fig. 3 Results of initial sediment calibration

The results of runoff and sediment calibration at the main outlet of the basin are presented in Figures 2 and 3. Further effort should be directed at discovering potential reasons for low performance of the simulated sediment. Possible reasons for over-estimation of sediment load and discharge are insufficient accounting of agricultural and industrial water use in the model, constructed flood control measures, land use changes and construction of roads and tunnels that can affect the local hydrology of the basin during the calibration period. Next we will use the calibrated validated model to assess the impact of climate change at the Gorganroud river basin on stream flow and sediment yield.